UNIVERSITY II SERIES

MODEL 530 SPECTROMETER

OPERATING AND INSTRUCTION MANUAL

BAIRD ATOMIC

CAMBRIDGE, MASSACHUSETTS

Warranty

Baird-Atomic, Inc. (the "Company"), warrants this equipment for a period of 1 year from the date of shipment as follows: it warrants that all equipment of its manufacture is free from defects in material and workmanship at the time of shipment. If within 1 year of shipment any equipment of the Company's manufacture develops defects in material or workmanship under normal conditions of operation, the buyer of the equipment may return it to the Company within 30 days of such failure, for repairs at the expense of the Company excluding transportation costs, or in the case of any defective part may return such part to the Company which will repair or replace the same at its expense excluding transportation costs. A further warranty of 1 year on the same terms shall be applicable to any part so repaired or replaced. Except for Dekatron glow tubes, this warranty does not extend to stock components not manufactured by the Company.

The Company shall not be liable for damage or destruction of instruments during delivery or caused by other than employees of Baird-Atomic, Inc.; in any event, liability shall not exceed the cost of replacement of defective parts upon prompt notification of such defect. For return of equipment or any part thereof under the terms of the foregoing warranty a letter should be forwarded to Baird-Atomic, Inc., Attention: Sales Service Department, 33 University Road, Cambridge 38, Massachusetts. It should state owner's name and address; model and serial number of equipment; the order number under which it was purchased; the date of failure and a description of the circumstances surrounding same. Upon receipt of such information, shipping instructions for return of equipment or parts thereof will be forwarded promptly.

UNIVERSITY II SERIES

MODEL 530

SPECTROMETER MANUAL

Second Edition, August 1964
Reprint, November 1965

CONTENTS

	Page
1. GENERAL DESCRIPTION	3
Spectrometer Definition	3
Digital-to-Analog Converter Definition	4
Spectrometer Specifications	5
General	5
Scaler-Timer	5
Analyzer	6
Amplifier	7
High Voltage Power Supply	9
Connections	9
DAC Specifications	11
Model 610 Printer Specifications	12
2. OPERATION	15
Installation	15
Grounding Considerations	15
Controls, Indicators and Connectors	16
General Operating Procedures	29
Scaler-Timer	29
Analyzer	33
High Voltage	35
Typical System Calibration	36
Proportional Counter Spectrum Application	37
Sample Changer	38
50 cps Operation Option	39

Page

Non-Synchronous Preset Count Option 39
Operating Procedures with DAC-Equipped Model 530 ... 40
DAC Calibration 43
X-Y Recorder Calibration 45

3. SPECTROMETER THEORY 49
System 49
High Voltage Power Supply 49
Amplifier 56
Analyzer 60
Scaler-Timer 65
100 kc Decade Counter 66
1 mc Decade Counter 71
Timer Countdown 71
Scaler Control 75
System Supply 79
Digital-to-Analog Converter 80

4. TROUBLESHOOTING 85

5. PARTS LIST 89
Model 530 Spectrometer Parts List 90
Digital-to-Analog Converter Parts List 94

APPENDIX 95
Model 530 Spectrometer Schematic Drawings 95
Digital-to-Analog Converter Schematic Drawings 95

Model 530 Spectrometer

Manual

MODEL 530 SPECTROMETER
Figure 1.1

CHAPTER
1

GENERAL DESCRIPTION

Spectrometer Definition

The Model 530 Spectrometer is a flexible, fully automatic, all solid-state instrument designed to perform the critical requirements of scintillation spectrometry. Spectrometer sub-units, each consisting of one or more printed circuit boards, are integrated for reliable, high speed compatible operation. Functionally, the spectrometer may be defined as consisting of these three main sections:

1. Scaler-Timer - a high speed, fully automatic 6-decade scaler and a 5-decade timer, with all presettable digits on count and time, and a background subtract operation mode.
2. Analyzer - an accurate single channel pulse height analyzer with window control featuring an all solid-state baseline advance; a fast, high gain non-overloading pulse amplifier featuring both a low impedance input (current sensitive) and a high impedance input (voltage sensitive).
3. High Voltage Power Supply - a DC-to-DC converter employing a high gain feedback amplifier to control the desired output level, and provide required regulation.

A system supply for powering the spectrometer is also included. The spectrometer, designed to operate directly into a

parallel printer, has the capability to automatically print out a full spectrum of 100 channels.

A compact steel cabinet houses spectrometer components; complete modular construction simplifies troubleshooting and maintenance. The front panel, hinged at the bottom, lowers for convenient access to all printed circuit boards. A wire stand positioned at the bottom of the cabinet allows inclined operation for control and viewing ease when used on a bench.

All circuits are built in modular fashion on 5" x 9" glass epoxy printed circuit boards, guided and held in position by means of two plastic guide strips. The 17 printed circuit boards each plug into a 23-pin connector mounted at the back of the card cage. Extender boards are also available; these permit troubleshooting the spectrometer while it is operating.

The system power supply, located behind the card cage, is mounted on a platform that may be pulled out for servicing after removing its mounting hardware. All wiring from the supply is through one terminal board.

All mode switches, of the slide variety, are conveniently mounted on a switch panel below the hinged front panel. Operating controls are also conveniently mounted on the front panel. Connections to other instruments are accomplished through the connector panel located at the rear of the spectrometer.

Digital-to-Analog Converter Definition

The digital-to-analog converter (DAC), a factory installed accessory, adds the facility of a digital ratemeter to the Model 530. Functioning as a digital ratemeter the unit is capable of measuring

the time rate of events occurring at either regular or random intervals. It presents this information as an analog signal at a set of rear connector terminals. Digital information taken from any three adjacent scaler decades, depending on range switch position, is presented by the DAC board as either a current of 0 to 1 milliamperes, or a voltage over the range of 0 to 100 millivolts. A 99-step output (x) is supplied for x-y recorder operation.

DAC circuitry, which is plugged into card position C14, is contained on a printed circuit board consistent with the modular design of the spectrometer.

Spectrometer Specifications

The published spectrometer specifications are fully as important as the instrument described, for the data provides a description necessary to correctly use the Model 530. Since Baird Atomic products benefit from a program of continuing evaluation and improvement, specifications are subject to modification.

General

Line Voltage	115 volts AC $\pm$15%, 60 cps (115 volts, 50 cps, or 220 volts, 50 cps option)
Input Current	0.9 A at 115 volts AC
Operating Temperature Range	+ 10°C to + 50°C

Scaler-Timer

Resolving Time	1 usec pulse pairs

Scaler-Timer (Cont.)

Maximum Continuous Count Rate	1 megacycle
Count Capacity	999, 999
Input	(negative 5 volts, internal from analyzer)
Preset Counts	All decades presettable from 0 to 9
Display	0 - 9 (incandescent lamps)
Time Base	0.1 second or 0.1 minute (derived from 60 cycle AC line)
Time Ranges	0.1 - 9999.9 seconds in 0.1 second increments or 0.1 - 9999.9 minutes in 0.1 minute increments
Time Capacity	5 decades presettable from 0 to 9

Analyzer

Modes	
Discriminator	Integral or Differential
Baseline Advance	Manual or Automatic
Baseline Range	0% to 100%
Window Range	0% to 100% of full scale baseline range
Linearity	$\pm$ 0.25% of full scale at any setting
Input Polarity	Positive

Analyzer (Cont.)

Input Voltage Range	0-10 volts
Input Impedance	1,000 ohms (minimum)
Input Pulse Shape	Rise time not critical. Typical 0.1 to 0.5 usec
Input Pulse Width	Not critical. Blanking inhibit level generated by upper level discriminator on leading edge. Removed only by action of lower level discriminator on trailing edge
Output Pulse	Negative 6 volts. 0.5 usec wide
Output Impedance	Less than 100 ohms
Resolving Time	Less than 1.0 usec
Baseline Temperature Stability	Manual Mode: 0.02% of full scale per ^{o}C Automatic Mode: $\pm$1 channel (1%) from 25^{o}C to 50^{o}C
Baseline Shift	1% of full scale for 60,000 cps average count rate

Amplifier

Input Modes	
Current	
Maximum Gain	10 volts/microampere
Input Sensitivity	1 microampere (full scale)
Input Impedance	100 ohms, approximately

Amplifier (Cont.)

Noise	0.02 microamperes rms referred to input
Pulse Shaping	0.1 usec input differentiating time constant
Output Pulse Shape	0.25 usec rise time, typical
Voltage	
Maximum Gain	1000
Input Sensitivity	10 millivolts (full scale)
Input Polarity	Negative
Input Impedance	10,000 ohms
Noise	0.2 millivolts rms referred to input
Pulse Shaping	10 usec input differentiating time constant
Output Pulse Shape	0.25 usec rise time, typical (decay time is function of pre-amplifier pulse shaping)
Input Pulse Shape	Not critical
Output Impedance	10 ohms, approximately
Voltage Range (nominal)	Positive 0-10 volts
Voltage Range (linear)	150% of analyzer full scale input
Linearity	$\pm$0.25% of full scale
Overload Recovery	Less than 10 usec for a 100 to 1 overload
Gain Sensitivity to Temperature	0.02% of full scale per ^{o}C

Amplifier (Cont.)	
Resolving Time	1 usec
High Voltage Power Supply	
Circuit	All solid-state
Output	500 to 2985 volts DC at 5 ma maximum
Polarity	Positive
Short Circuit Protection	Fused
Line Regulation	0.01% maximum from 105 to 125 volts AC
Load Regulation	0.01% maximum from 0 to full load
Noise and Ripple	150 mv peak-to-peak
Stability	0.03% per day maximum
Temperature Coefficient	$\pm$0.005% of full scale per ^{o}C from 10 ^{o}C to 50 ^{o}C
Connections	
Preamplifier	Amphenol 7-pin (3102A-16S-1S) Signal Input Ground B+ 18 volts at 10 ma -18 volts at 10 ma
Signal Current Input	MHV (input to amplifier for current mode)
Signal Voltage Input	BNC (input to amplifier for voltage mode)

Connections (Cont.)

Printer Readout (Scaler-Timer)	Amphenol 50-pin (57-40500). Contains all decade outputs, command signal for printer. BCD 1-2-4-8 output from each decade in Scaler and Timer. One level - 0.0 volts $\pm$ 0.5 volts Zero level - Negative 10 volts $\pm$ 2 volts Print Command - A negative 15 volt pulse with a 45 millisecond decay that occurs when count stops. Inhibit Start - Generated by Printer switch closure to ground occurring no more than 50 milliseconds after start of print command. Duration less than 200 milliseconds.
Analyzer Output	BNC (-6 volts 0.5 usec wide)
Voltage Outputs	1.5KV high voltage output (MHV) 3KV high voltage output (MHV)
AC Power	115 volts AC 60 cycle at 850 ma (50 cycle optional)
Dimensions	17" wide x 7" high x 15" deep
Weight	Approximately 38 pounds

DAC Specifications

Range Positions	1 to 1K, 10 to 10K, 100 to 100K and 1K to 1M
Readout Intervals	0.1 to 9999.9 seconds or minutes (analyzer MANual mode); 0.1 to 99.9 seconds or minutes (analyzer AUTOmatic mode) in 0.1 second or minute increments
Dead Time	0.2 second per readout (if printer is not used)
Output	0 to 1 milliampere or 0 to 100 millivolts
Output Impedance	Approximately 10 ohms for 0 to 10 millivolts; approximately 100 ohms for 0 to 100 millivolts; approximately 1.5 kilohms for 0 to 1 milliampere
X Drive Output	Approximately -0.9 volts at zero to approximately -9.7 volts at full scale
Maximum X Drive Current	5 milliamperes
Accuracy	$\pm$ 1% of full scale count
Stability	$\pm$ 1% of full scale per day
Linearity	Is less than $\pm$ 3% of full scale over temperature range of 25°C to 50°C

Model 610 Printer Specifications

Baird Atomic offers the Model 610 Printer to be used with the Model 530 Spectrometer. Printer specifications are given below.

General	
Power	115 volts AC $\pm$ 10%, 60 cps approximately 0.7A, 45 watts
Cable and Connector	Amphenol 50 pin (57-30500)
Printing Speed	3 lines per second maximum
Printing Format	Lists vertically on standard adding machine tape. Column 1 to extreme right.
Paper Requirements	Standard 2-1/4" roll tape
Printing Ribbon	7/16" two color adding machine ribbon
Number of Columns Used	11
Maximum Column Capacity	12
Data Arrangement	Timer - column 12 to column 8 Scaler - column 6 to 1 For automatic baseline mode, columns 12 and 11 are used for channel numbers.
Inputs and Output	
Data Input Code	4 line BCD 1-2-4-8 code. Parallel entry to all columns simultaneous with print command

Inputs and Output (Cont.)	
Levels	Binary one - 0 ± 0.5 volt Binary zero - -8 to -20 volts
Input Resistance	10 megohms
Print Command	Change from binary one to binary zero, lasting for 40 milliseconds, starts print cycle
Inhibit Start	Generated by printer. Switch closure to ground occurring no more than 50 milliseconds after start of print command. Duration is less than 200 milliseconds.
Dimensions	
Portable Case	9" wide x 10" high x 13" deep
Printer	8" wide x 8" high x 16" deep
Weight	Approximately 35 pounds

CHAPTER
2

OPERATION

Installation

No special precautions other than those normal with commercial type laboratory equipment need be taken. The line cord should be plugged into a 3-wire system (third wire equipment ground) to keep the chassis at the same potential as other equipment.

If the spectrometer is used on a bench, nothing that would tend to block air circulation should be placed on top. Four rubber feet are provided to allow air to enter the ventilated bottom of the cabinet and exit through the top. When used in rack mounting applications, take care not to exceed the maximum operating temperature specified.

Grounding Considerations

The spectrometer, a very sensitive measuring device, is capable of accurately analyzing high speed signals in the fraction of millivolt and fraction of microampere range. In this type of low-level measuring system the grounding must be carefully controlled to eliminate loops and noise pickup.

Within the spectrometer the signal wiring from the amplifier input connectors is shielded to the amplifier printed circuit board input pins.

However, it is necessary to consider how the phototube and/or preamplifier are connected to the spectrometer amplifier inputs. If the preamplifier and tube are housed in a metal chassis, the chassis should make electrical connection with the spectrometer chassis through the shield of the coaxial cable connecting the two. Superfluous connections between the two chassis can cause a significant increase in noise. When using a preamplifier that does not derive its DC power from the spectrometer (such as do all the preamplifiers in Baird Atomic probes and well counters) take care to ensure that an unwanted ground loop does not occur through equipment ground in a 3-wire power system.

Controls, Indicators and Connectors

All spectrometer controls and indicators, except the SAMPLE CHANGE and HV RANGE controls which are located on the rear panel, are located on the front panel and conveniently grouped by subunit function as shown in Figure 2.1. In those spectrometer units having the DAC feature, the DAC controls and connector are located on the rear panel. The controls are functionally separated: all mode switches are mounted on the lower switch panel and all operating controls on the hinged main front panel. Chart 1 relates the controls and indicator by function.

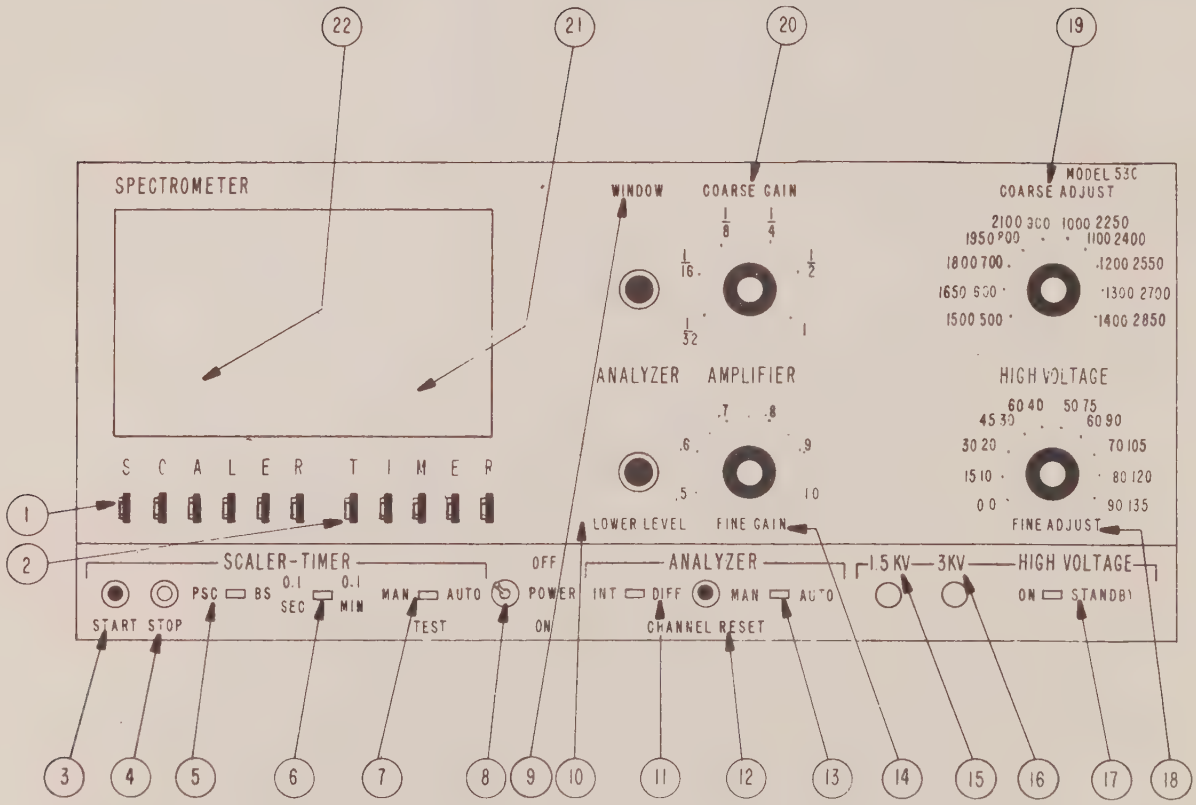
All connectors for connecting input source and printer, and fuses for the line and high voltage are mounted on the rear

connector panel. Figure 2.2 shows the fuses, rear connectors, and the HV RANGE and SAMPLE CHANGER controls; Chart 2 complements the figure. Figure 2.2 also illustrates DAC controls and the connector which are complemented by Chart 3.

FRONT PANEL CONTROLS AND INDICATORS

Chart 1

REF. NO.	CONTROL or INDICATOR	FUNCTION
(1)	SCALER (Preset Count)	a) Stops scaler when count reaches preset number if PSC - BS switch is in the PSC position b) Resets scaler to zero first time count reaches preset number if PSC - BS switch is in BS position
(2)	TIMER (Preset Time)	Stops scaler-timer when time reaches preset number; both PSC and PST are overriding type controls; if analyzer MAN-AUTO switch is in AUTO position, first two switches are disconnected



FRONT PANEL CONTROLS AND INDICATORS

Figure 2.1

FRONT PANEL CONTROLS AND INDICATORS
Chart 1 (Cont.)

REF. NO.	CONTROL or INDICATOR	FUNCTION
(3)	START	Resets, then starts scaler-timer
(4)	STOP	Stops scaler-timer synchronously
(5)	PSC-BS	a) PSC - 6 scaler thumbwheel switches used for preset count b) BS - 6 scaler thumbwheel switches used for background subtract
(6)	0.1 SEC - 0.1 MIN	Selects clock base for timer
(7)	MAN - AUTO TEST	a) MANual - scaler-timer under control of START-STOP push-buttons b) AUTOmatic - scaler-timer stops on PST or PSC, waits for printer to print, then automatically resets and starts c) TEST - timer clock base applied to scaler as test input
(8)	OFF POWER ON	Connects power supply to line

FRONT PANEL CONTROLS AND INDICATORS
Chart 1 (Cont.)

REF. NO.	CONTROL or INDICATOR	FUNCTION
(9)	WINDOW	Controls window width when INT-DIFF switch is in DIFF; setting from 0 to 100% of full scale input (10 volts)
(10)	LOWER LEVEL	Controls baseline discrimination level from 0 to 100% when MAN-AUTO switch is in MAN
(11)	INT - DIFF	a) INTegral - WINDOW control disabled; output pulse occurs when input exceeds lower level discriminator b) DIFFerential - output pulse occurs when input pulse falls within window determined by WINDOW and LL controls
(12)	CHANNEL RESET	Resets baseline to channel 00; used only when MAN-AUTO switch is in AUTO

FRONT PANEL CONTROLS AND INDICATORS
Chart 1 (Cont.)

REF. NO.	CONTROL or INDICATOR	FUNCTION
(13)	MAN - AUTO	a) MAN - baseline discrimination level controlled manually by means of LOWER LEVEL potentiometer b) AUTO - baseline discrimination level controlled and advanced automatically by means of digital-to-analog converter; baseline steps through 100 channels in 1% increments
(14)	FINE GAIN 1.0 - .5	Multiplier for COARSE GAIN switch; allows continuous setting between coarse ranges
(15)	1.5KV	Pilot lamp indicates that power is being applied when lighted
(16)	3KV	Pilot lamp indicates that power is being applied when lighted
(17)	ON - STANDBY	a) ON - high voltage connected to output connector

(Cont. next page)

FRONT PANEL CONTROLS AND INDICATORS

Chart 1 (Cont.)

REF. NO.	CONTROL or INDICATOR	FUNCTION
(17) (Cont.)		b) STANDBY - disconnects low voltage from transformer primary center tap; secondary still connected to one of the output connectors
(18)	FINE ADJUST 0 - 90 volts and 0 - 135 volts	Adjusts voltage in 10 volt steps or adjusts voltage in 15 volt steps; reading adds to COARSE ADJUST reading
(19)	COARSE ADJUST 500 - 1400 volts and 1500 - 2850 volts	Adjusts voltage in 100 volt steps or adjusts voltage in 150 volt steps
(20)	COARSE GAIN $1 - \frac{1}{32}$	Changes amplifier gain in binary steps from 1 to 1/32, where 1 is equivalent to amplifier voltage gain of 1000 or current gain of 10 volts per microampere
(21)	TIMER	Indicates five digits of total elapsed time since last scaler

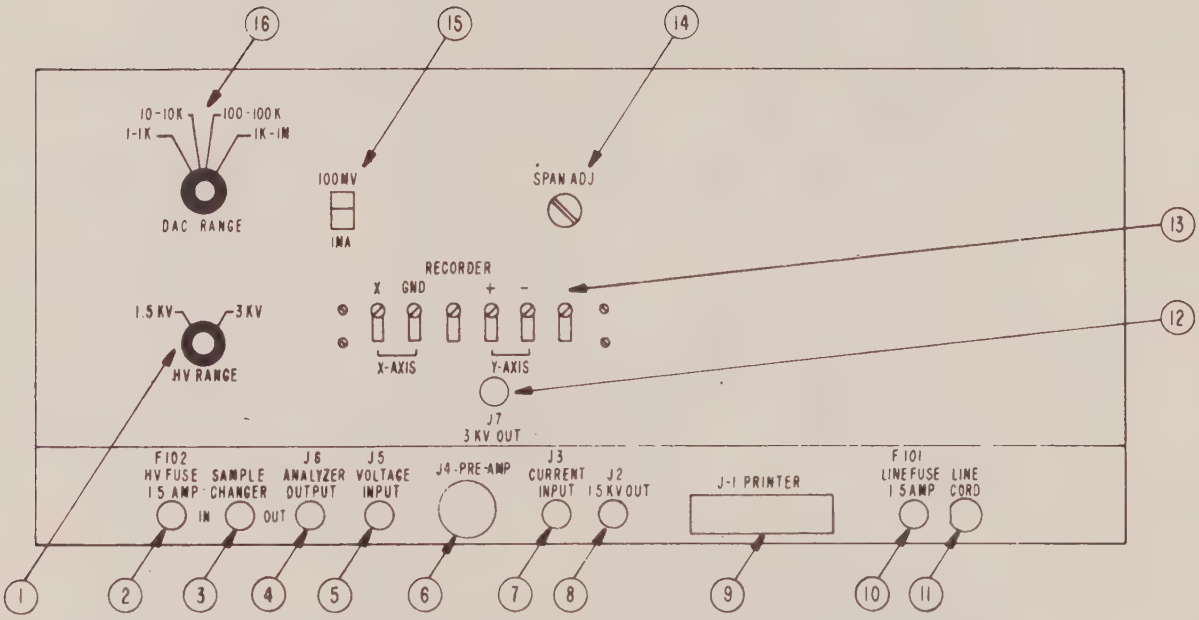
(Cont. next page)

FRONT PANEL CONTROLS AND INDICATORS
Chart 1 (Cont.)

REF. NO.	CONTROL or INDICATOR	FUNCTION
(21) (Cont.)		start pulse; least significant digit is 0.1 second or 0.1 minute depending upon position of time base switch; if analyzer MAN-AUTO switch is in AUTO, the first two digits represent baseline channel number as percent of full scale rather than most significant digits of timer; if SAMPLE CHANGER switch is set to IN the first two digits represent sample number
(22)	SCALER	Indicates total count in scaler decades; most significant digit is furthermost to left

REAR PANEL CONTROLS, FUSES AND CONNECTORS
Chart 2

REF. NO.	CONTROL, FUSE or CONNECTOR	FUNCTION
(1)	1.5KV-3KV HV RANGE	Selects 1.5KV or 3KV range from power supply



REAR PANEL CONTROLS, FUSES AND CONNECTORS

Figure 2.2

REAR PANEL CONTROLS, FUSES AND CONNECTORS
Chart 2 (Cont.)

REF. NO.	CONTROL, FUSE or CONNECTOR	FUNCTION
(2)	F102 H. V. FUSE 1.5 AMP (High Voltage Power Supply)	Fuses -18 volt supply to series regulator that drives high voltage transformer primary center tap
(3)	SAMPLE CHANGER IN - OUT	Places spectrometer under sample changer control when set to IN position
(4)	J6 ANALYZER OUTPUT (Analyzer)	Connects directly to analyzer output; 0.5 microsecond, 6 volt negative-going pulse from ground baseline
(5)	J5 VOLTAGE INPUT (Amplifier)	AC coupled to high impedance voltage input amplifier; parallels J4 signal input; normally connected to preamplifier output

REAR PANEL CONTROLS, FUSES AND CONNECTORS
Chart 2 (Cont.)

REF. NO.	CONTROL, FUSE or CONNECTOR	FUNCTION
(6)	J4 - PRE-AMP (Amplifier)	AC coupled to high impedance voltage input of amplifier; contains ± 18 volts DC, 10 ma, to supply preamplifier power; may be connected directly to any standard Baird Atomic scintillation probes and well counters
(7)	J3 CURRENT INPUT (Amplifier)	AC coupled to low impedance current input of amplifier; may be connected directly to phototube anode with maximum DC level of 3000 volts
(8)	J2 1.5KV OUT (High Voltage Power Supply)	Connects to source of high voltage; 1500 volts DC maximum

REAR PANEL CONTROLS, FUSES AND CONNECTORS

Chart 2 (Cont.)

REF. NO.	CONTROL, FUSE or CONNECTOR	FUNCTION
(9)	J-1 PRINTER (Scaler-Timer)	Connects to 4-line output of each of the six scaler and five timer decades; also contains control signals for Model 610 Printer
(10)	F101 LINE FUSE 1.5 AMP	Primary line fuse
(11)	LINE CORD (System Supply)	Connects to power outlet; normally 115 volts AC, 60 cps, the third wire tied to equipment ground
(12)	J7 3KV OUT	Connects to source of high voltage; 3000 volts DC maximum

DAC CONTROLS AND CONNECTORS

Chart 3

REF. NO.	CONTROL or CONNECTOR	FUNCTION
(13)	RECORDER	Input connections to accessory equipment are made on this connector
(14)	SPAN ADJ	Calibrates recorder full scale
(15)	100MV - 1MA	Selects either of two recorder operations: 0 to 1 milliampere or 0 to 100 millivolts full scale (with 0 to 10 millivolts optional)
(16)	DAC RANGE	Selects the three adjacent scaler decades for readout by the DAC board

General Operating Procedures

The Model 530 Spectrometer is a versatile instrument with several possible operation modes. These operating procedures are intended as a guide only to assist the operator in initial setup. For this discussion, it is convenient to divide the spectrometer into its three main sections: Scaler-Timer, Analyzer, and High Voltage.

Scaler-Timer

The scaler-timer contains three mode switches that must be set up as well as the 11 thumbwheel switches for presetting count or time. The clock base for the timer is selectable as 0.1 second or 0.1 minute increments. The total range of the timer can be 9999.9 seconds or 9999.9 minutes. The PSC-BS switch selects the use of the scaler thumbwheel switches for either preset count or for background subtract function. The 3-position MAN-AUTO-TEST switch determines whether the scaler will start and stop automatically or be under control of the pushbuttons. In TEST, the timer clock base is applied as an input to the scaler for checking.

Preset time and preset count controls work on an overriding basis. The scaler will stop on whichever preset number is first arrived at. When it is desirable to stop on preset time, set the desired time interval into the timer switches. If background subtract is not to be used, set the PSC-BS to the PSC position and set the scaler thumbwheel switches to all nines. Then the scaler will stop on the number preset in the timer. If activity is greater than anticipated and the full scale capacity is reached before the time that was preset, the scaler stops when the preset count of 999,999 is

reached. The operator will then still get a valid reading. If the scaler did not stop when at full scale, the operator would have no positive reference for it.

When it is desirable to stop on a preset count to ensure sufficient statistical accuracy, preset the count in the scaler switches, put the PSC-BS switch in PSC position, and preset all nines in the timer switches. The scaler will then continue to count until it reaches the preset count; if the activity is less than expected, it counts until it reaches the preset time. Sometimes it may be necessary to establish both a preset count and a preset time. For example, if it is desirable to automatically printout a spectrum with 1% statistical accuracy at each baseline setting, 1% accuracy requires that 10,000 counts be accumulated. In the region of the photo peak, assume that 10,000 counts can be obtained in a reasonable time. However, in the valley before the peak, it may take an exorbitantly long time to reach this count. It is desirable in this situation to preset a maximum time that the spectrometer should dwell at any setting. Since the controls are overriding this is done simply by setting in the preset count and time wanted. When either preset time or preset count is not to be used, always set up switches to a high number: all nines, say, to disable it. Never set all switches to zero, for this results in an invalid stop.

When the scaler is stopped with the preset count control, it is normally synchronized to the timer. So when the preset count is reached it does not immediately stop the scaler, but conditions it so that the next timer clock pulse will stop it. Since the clock pulse occurs in either 0.1 second or 0.1 minute intervals, it is possible to accumulate further counts while waiting for the stop signal. But when the scaler does stop, it will show the exact

number of counts that occurred in the time interval displayed.

Synchronized preset count is more precise than non-synchronous. But when it is desirable to stop on the exact number preset in the scaler, simply add one jumper to the scaler control board to disable the synchronous feature. (The non-synchronous preset count option is discussed below.)

The background subtract feature is used when it is desirable to obtain final count which is above the present background. In determining the background, connect the detector and phototube to the spectrometer, remove the radioactive source and measure the count rate present for some time. Calculate total counts expected during the actual test by multiplying the count rate by the number of minutes or seconds that the test will be conducted. Then preset the time, put PSC-BS switch in the BS position, preset expected background in scaler switches, replace source and start the scaler. The scaler will count until it reaches the number preset in its switches. When this number is reached, the scaler only will reset and then continue to count. Meanwhile, the timer will continue until it reaches the preset time; it will then stop the scaler. In background subtract mode, the scaler-timer can be stopped only by preset time or manual stop.

When the 3-position mode switch is in MAN, the scaler is started with the START pushbutton, actually a reset-start operation since both the scaler and timer are reset to zero before starting. The stop function is accomplished by preset count, preset time or manual stop, whichever occurs first. If a printer is connected to the spectrometer, the contents of the timer and scaler at the end of the counting cycle are printed out in parallel each time the scaler is stopped.

When the mode switch is in AUTO the scaler resets, starts and stops automatically. When either preset time or count is reached the scaler stops. If no printer is connected, the first clock pulse after stopping conditions the START circuits and the second clock pulse causes the scaler to reset and start; when a printer is connected, a print command signal, generated when stopping the scaler, starts the printing cycle. The printer returns an inhibit start signal, taking from 200 to 250 milliseconds, which prevents the scaler from starting until the printer no longer requires the input data. Two clock pulses after the end of the inhibit start restart the scaler. When the clock base for the timer is 0.1 second, the total time the scaler is stopped varies between 0.3 and 0.4 second; when the clock base is 0.1 minute, the scaler is always stopped for two clock periods, 12 seconds. When it is desirable to stop the scaler and prevent it from restarting, the mode switch must be moved from AUTO to MAN.

In TEST, the input from the analyzer is disconnected and the timer clock base instead is connected to the scaler input. The scaler-timer always operates under manual control when in TEST. Since the same signal is driving both scaler and timer, the two counters will operate in unison. If the instrument stops on preset time, the numbers displayed on the scaler and timer will match the preset time number. If, instead, preset count does the stopping, the number displayed will be one higher than that set in the switches. Since preset count is synchronized, a conditioning signal only is generated when the count is reached in the scaler. The actual stop signal is the next clock pulse; in TEST it is also the input to the scaler.

If the non-synchronous preset count option is employed,

the scaler-timer stops immediately upon reaching the preset number. Then the display will coincide with the switch numbers.

Analyzer

The amplifier allows the operator the option of a low input impedance current input, or a high impedance voltage input. The current input allows the phototube to be connected with up to 25 feet of coaxial cable to the amplifier with no intermediary preamplifier. It also allows several tubes to be summed directly into one amplifier. A high voltage capacitor is included in the amplifier input to allow up to 3000 volts DC level to be present at the input. The voltage input of the amplifier is used in conventional fashion -- driven from the low output impedance of a preamplifier. The input circuit consists of capacitor coupling into a 10,000 ohm resistor.

The phototube is connected to the current input via J3, a MHV connector. The preamplifier may be connected to J4, a 7-pin Amphenol if it is a standard Baird Atomic preamplifier, or to J5, a BNC connector. When using the current input J3 the voltage input may be left floating or shorted by means of J5. When using either voltage input, current input J3 should never be shorted. Leave open if not in use.

There are two amplifier gain controls: a COARSE GAIN which varies the gain by factors of 2 in six steps, and a FINE GAIN which is a 1-turn potentiometer with a locking type knob. The range of adjustment is from one-half to one times the COARSE GAIN setting, allowing continuous adjustment from the lowest to the highest gain settings. The maximum gain is 1000 for the voltage input, and 10 volts per microampere for the current input.

There are two mode switches for the analyzer: one selects integral or differential operation, the other selects either MAN or AUTO baseline advance. In INT an output appears from the analyzer whenever an input pulse exceeds the lower level discrimination level. In DIFF an output appears whenever the input pulse exceeds the lower level discrimination level but not the upper level as determined by the WINDOW setting.

In MAN the baseline discrimination level is determined by the setting of the LOWER LEVEL 10-turn potentiometer. In AUTO the baseline discrimination level is determined automatically by an all solid-state digital-to-analog converter. Here the two decade counters normally used for the two most significant digits of the timer indicate instead the channel number as a percentage of full scale. The output of the digit channel counter is converted to 100 discrete voltage steps from 0 to 99% of full scale by means of a digital-to-analog converter. The LOWER LEVEL potentiometer has no function in this mode. The channel counter advances by one each time the scaler-timer is started. The baseline voltage then remains constant at the value indicated by the channel counter while counts are accumulated in the scaler. The baseline remains at this level until the scaler stops, then starts again. The CHANNEL RESET pushbutton allows the channel counter to be reset to zero at any time. When the analyzer is in AUTO the two thumbwheel switches associated with the channel counter are disconnected from their normal role as part of preset time control. They may be at any arbitrary setting without affecting the operation.

The automatic baseline feature allows a complete spectrum to be printed out automatically. Set the analyzer to AUTO and reset

the channel counter. Preset either time or count (or both) in the scaler-timer and set the scaler-timer in the AUTO.

The scaler will automatically start, advancing the channel counter to 1%. Counts are accumulated until either preset time or count is reached, then the scaler stops. If a printer is connected, the contents of the 2-digit channel counter, 3 digits of time and 6 digits of count are printed out. When the printer no longer requires the information the scaler resets, the channel counter advances to channel two, and then the scaler restarts. In this manner a complete 100 channel spectrum may be automatically printed out.

If it is desirable to advance to a particular channel rapidly, and then to remain there, or to more slowly advance beyond the channel, set the preset time for the shortest period, 0.1 second, and set the scaler in AUTO, the printer in STAND-BY. The baseline will advance rapidly: 0.3 second per channel. When approaching the desired setting, switch the scaler to MAN which will cause the scaler to stop. Now set for desired preset time or count, set printer in PRINT and return scaler to AUTO. A partial spectrum may then be printed in the region of greatest interest. After the channel counter reaches 99 it will reset to zero on the next start signal, repeating the spectrum until the scaler is permanently stopped by setting it to MAN.

High Voltage

The high voltage may be applied to the phototube by means of MHV connector J2. Detectors requiring more than 1500 volts must be connected to J7.

There is one mode switch for the high voltage, ON-STANDBY. In the ON position the voltage indicated by the front

panel switches will be present at the J2 or J7 connector. In the STANDBY position the primary center tap of the high voltage transformer is connected to ground rather than to a regulated DC voltage. The secondary remains connected to J2 or J7 with zero volts across it in the STANDBY condition. Of the two front panel controls of the high voltage (Chart 1), the setting of FINE ADJUST is added to the COARSE ADJUST to arrive at the exact voltage appearing at J2 or J7.

The supply is protected against short circuits by means of fuse F102 (located on the rear connector panel). The fuse is series with the -18 volt regulator connected to the primary center tap. Because of this no high voltage is present at the fuse terminals.

Typical System Calibration

The system may be calibrated to read directly in energy. Set it up to do so in the following manner:

1. Set scaler to PSC, 0.1 SEC, MAN mode.
2. Preset a high count and long time in switches.
3. Place analyzer in INT position, MAN mode.
4. Set the high voltage to STANDBY.
5. Connect high voltage cable to phototube and connect phototube to amplifier, either directly into J3 or via preamplifier to J4 or J5.
6. Set high voltage to ON.
7. Using a standard source, set LOWER LEVEL control to correspond to isotope photopeak. For example, if Cs^{137} is used, set LOWER LEVEL to 66.2% of full scale; set high voltage

to between 900 to 1000 volts.

8. Set amplifier gain at minimum -- COARSE GAIN at 1/32 and FINE GAIN at 0.5.
9. Press START button and observe scaler as the gain of the amplifier is increased with the COARSE GAIN setting.

When the scaler starts counting, return to the previous COARSE GAIN setting and vary the FINE GAIN control until activity just begins in the scaler. To get the exact setting, now place analyzer in DIFF, set about 5% WINDOW, and adjust FINE GAIN for maximum counting rate in scaler. Once set, the fine gain control can be locked into position. To check the setting, set analyzer in AUTO, preset time for 0.1 second, set scaler in AUTO, and print out a fast spectrum.

It takes less than 40 seconds to print out a complete spectrum in this fashion; the operator can then rapidly obtain a complete check.

Proportional Counter Spectrum Application

Although the general operating procedures have been concerned with scintillation spectrometer applications, the same general procedure can be employed to obtain a proportional counter spectrum.

Typical settings for plotting the 14.4 KEV peak of a Co^{57} spectrum with a proportional tube using 90% xenon - 10% methane fill are as follows:

1. Cs^{210} preamplifier gain set at x10.
2. HV set at 2030 volts.
3. AMPLIFIER FINE GAIN set at 0.5.
4. AMPLIFIER COARSE GAIN set at 1/4.
5. ANALYZER WINDOW = 1%.

The counter input cable to the preamplifier should be approximately 7-1/2 inches in length.

The resolution of the 14.4 KEV photopeak obtained with this application should be approximately 12%.

A photopeak is obtainable using the current input mode but the resolution, tests show, is much poorer on account of increased noise caused by the cable (maximum gain of 1000 is necessary as well as higher voltage for this mode of operation) and the input pulse characteristic.

Sample Changer

The SAMPLE CHANGER switch S11 when set to IN places the spectrometer under the control of a sample changer; when the switch is set to OUT, operation remains as described above.

For sample changer operation set the SAMPLE CHANGER switch to IN, the analyzer to AUTO, and the scaler-timer to AUTO. In this mode the baseline is set manually with the LOWER LEVEL control.

The first two timer decades indicate sample number rather than time. Control signals from the sample changer are brought in through the 50-pin connector, J1 (see Figure 2.2 and Chart 2).

Two control signals, the Index Advance and Index Reset, synchronize the two sample counter decades to the sample number being analyzed. A third control lead provides the Inhibit Start signal to the scaler control which prevents the counting operation until the sample is correctly positioned.

50 cps Operation Option

The Model 530 Spectrometer is supplied to be operated with a 115 volt, 60 cps power source, but 50 cps operation at 115 volts, or 220 volts are offered as options. The only component difference between a spectrometer using the 60 cps power source, or one using the 50 cps source is in the system power supply transformer.

Since the frequency source for the timer is derived from the line voltage, it is necessary to make a change also on the timer countdown board, C8 (Figure 3.1). The change from 60 to 50 cps operation is done very simply -- by changing the location of one jumper. (Baird Atomic Timer Countdown Schematic D-30181 and Component Layout C-30186 give full details on the jumper change.)

Non-synchronous Preset Count Option

Normally the spectrometer is supplied with synchronous preset count. When the scaler arrives at the preset count it is conditioned to stop but does not actually stop until the next clock pulse comes from the timer. Then the exact counts per unit time are displayed. Since some operators prefer not to have synchronized preset count (so the scaler will stop on the exact count preset)

an option is provided which disables the synchronous feature. Figure 3.10 shows how the change may be made on the scaler control board merely by adding a jumper between A and B.

Operating Procedures with DAC-Equipped Model 530

Operation of the Model 530 Spectrometer as a digital ratemeter in no way affects its normal operation. Available spectrometer operating modes are unimpaired while remaining useful for extending spectrometer utility as a digital ratemeter.

Counting rate can be monitored by a recorder just as with a conventional ratemeter, and presentation will be made in stepwise fashion, indicating the actual counts per reading (within 1%) instead of the random statistical fluctuations of the conventional recorder.

Selection of the DAC range is simplified by consulting Chart 4 which illustrates the scaler decades as they are observed from the front of the spectrometer. Note that the DAC RANGE positions shown in Figure 2.2 indicate the applicable total count range less one count. In range 10-10K, for example, although it is possible to accumulate a greater or fewer number of counts, the actual range covered by the DAC section is from 10 counts to 9999 counts. The last digit in each case is not registered as part of the analog output. The same considerations are applied to the remaining range positions.

SCALER DECADE/DAC RANGE SWITCH POSITION RELATIONSHIPS

Chart 4

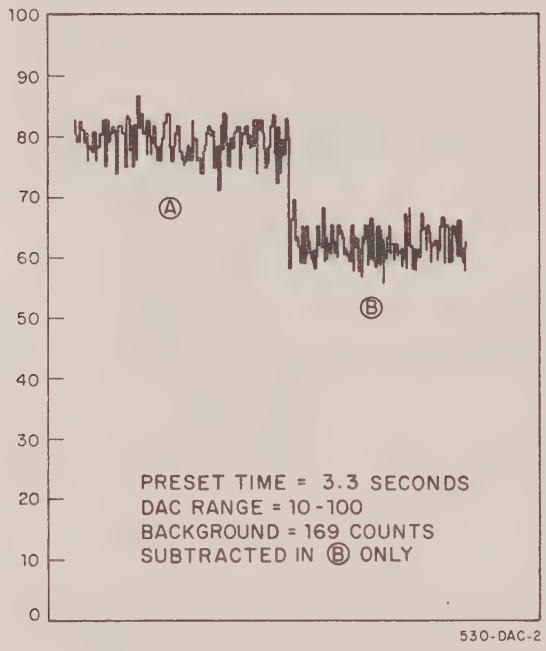
	COUNTS						
	DECADE POSITIONS						DAC RANGE
COUNTS	100Ks	10Ks	1Ks	100s	Tens	Units	SWITCH POSITIONS
From				0	0	0	1-1K
To				9	9	9	
From			0	0	1	X	10-10K
To			9	9	9	X	
From		0	0	1	X	X	100-100K
To		9	9	9	X	X	
From	0	0	1	X	X	X	1K-1M
To	9	9	9	X	X	X	

In Chart 4 the boxes designated with an X indicate that any digit may appear without having an effect on the analog output; if digits other than zero appear in the unmarked boxes an overflow has taken place and the analog reading is in error. When a printer is used simultaneously with the DAC, the numbers registered by the printer will be a true reading unaffected by overflow or other inherent errors in the DAC section.

Counting time or time constant for operation as a digital ratemeter is controlled by scaler-timer switch settings.

The background subtract feature in the Model 530 can be made a part of the digital ratemeter operation: resultant recorder trace will simply show the total count less a fixed number of counts as determined by the preset count switch (see Figure 2. 3).

The only limitation imposed by the digital ratemeter is that it can read only the three most significant digits of the total count. If the maximum total count is exceeded, the surplus will not be recorded and a false reading will result.



TYPICAL PLOT BEFORE AND AFTER BACKGROUND SUBTRACT FOR THE TWO LEAST SIGNIFICANT DECADES AND A 10MV RECORDER

Figure 2.3

In most cases, this condition is not intolerable because it is readily identified by previous knowledge of the character of the source. Assuming an average reading of 90 to 99 percent of full scale, if an occasional reading is suddenly recorded in the range of 0 to 10 percent an overflow has resulted. The extrapolated reading can be assumed by adding 10 in front of the total counts. As an example, if the average counts per time interval were 950 and the recorder suddenly showed a reading of 16, the total would be taken as 1016 counts.

This situation can be avoided by changing the time interval to a shorter time or advancing the DAC switch by one position and

increasing the preset time for a total counts reading nearer 50% of the most significant decade counting.

In plotting a spectrum it may be necessary to tolerate overflow for the first few steps of the plot to obtain a substantial reading of the photopeak. Aside from appearance, this does not detract from the plot since noise is still being counted in this region. Figures 2.4 and 2.5 show typical spectra for Cs^{137}. In Figure 2.5 note the very low readings resulting from overflow at the start of the spectrum.

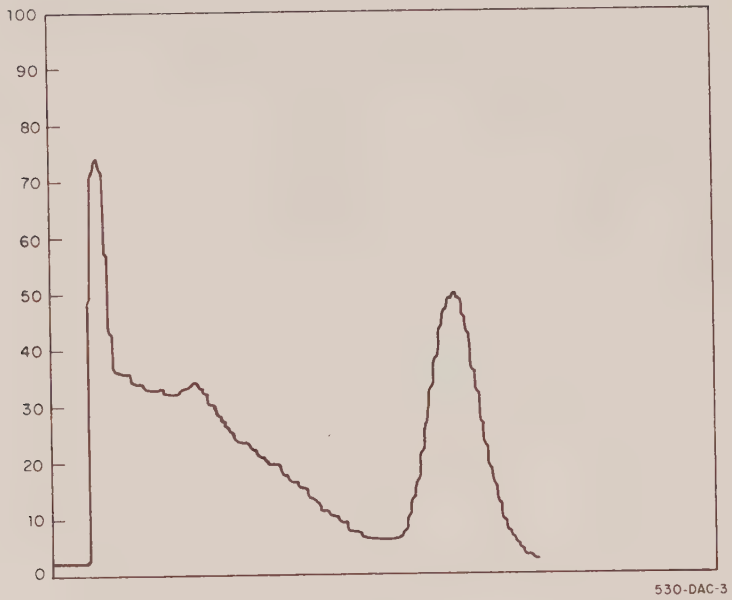
DAC Calibration

Although the DAC section was tested and calibrated at the factory for use with a recorder, it may be necessary to recalibrate the unit to correct for differences existing between the factory test recorder and a different recorder. Referring to Figures 2.1 and 2.2, recalibrate the DAC section in the following manner:

1. Set the recorder input switch to either 100 millivolts or 1 milliampere depending on the type of recorder used.
2. Connect the recorder, either 0 to 1 milliampere or 0 to 100 millivolt, across the minus (-) and plus (+) terminals on the RECORDER terminal strip.

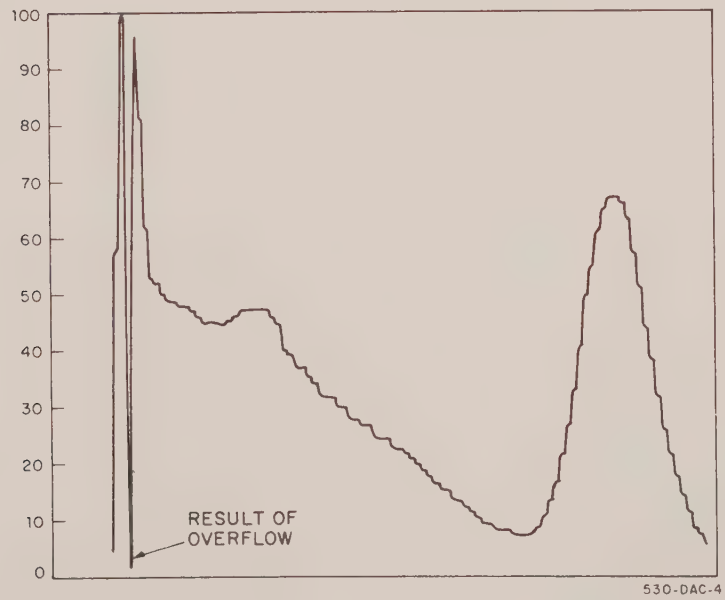
Turn on the spectrometer and calibrate the SPAN ADJ control on the rear panel as follows:

1. Set the SCALER-TIMER and ANALYZER mode switches to the MAN position; set the DAC RANGE switch in any position, preferably one of the higher



Cs^{137} SPECTRUM TAKEN WITH MODEL 530 DAC

Figure 2.4



Cs^{137} SPECTRUM USING MODEL 530 DAC, SHOWING OVERFLOW

Figure 2.5

positions; and reduce the amplifier gain so that the scaler will not register noise counts.

2. Set the HIGH VOLTAGE switch to STANDBY. Then, in turn, depress the START button and the STOP button. There should be zero counts on the scaler but the recorder will assume some arbitrary position based on the previous counts reading. Ignore this reading.
3. Depress the START button again. The recorder should read zero. If it does not, adjust the recorder zero set control.
4. Set the SCALER-TIMER mode switch to TEST, the DAC RANGE switch on the 1-1K position, the time switch on 0.1 sec, the preset time switches to 99.9, and the preset count switches to any value higher than 1000.
5. Depress the START button. When 99.9 seconds have elapsed the scaler-timer should stop counting at 999 counts.
6. Depress the START button and set the SPAN ADJ control for a recorder reading of 100% of full scale to correspond with the observed reading on the scaler.

The DAC section is now calibrated and ready for use.

X-Y Recorder Calibration

If an x-y recorder is used, the calibration procedure for the

y-axis input is the same as that described above. Calibrate the x-axis input in the following manner:

1. Connect the recorder x-axis input terminals to the Model 530 Spectrometer terminals marked X and GND. Observe the proper polarity and range of the recorder in use.
2. Set the ANALYZER MAN-AUTO switch to AUTO and depress the CHANNEL RESET pushbutton. The two most significant digits in the timer will drop to zero.
3. Adjust the recorder x-axis zero set control for recorder zero.
4. Set the spectrometer SEC-MIN switch to the 0.1 SEC position and set the preset time to 0.1.
5. Set the MAN-TEST-AUTO switch to the AUTO position. The timer should now repeatedly count to 0.1 (preset time), and reset. With each cycle the channel decades (the two most significant digits of the timer section) should advance one digit and the recorder x-axis should advance in equal increments across the sheet with a magnitude depending on the recorder gain settings.
6. When the channel number has just exceeded 90, set the MAN-TEST-AUTO switch to the MAN position, and advance the channel number manually by depressing the START pushbutton after each preset time cycle until channel number 99 is reached.

7. Start the scaler once more and adjust the recorder gain control for a reading of 99% of full scale.

CHAPTER
3

SPECTROMETER THEORY

System

All components necessary to perform high speed, differential scintillation or proportional spectrometry -- a stable high voltage supply, an amplifier-analyzer, and a scaler-timer -- are provided in the Model 530 Spectrometer. Figure 3.1, the overall spectrometer logic diagram, illustrates functional relationships.

Digital-to-analog converter (DAC) theory, which applies only to those spectrometers equipped with the DAC feature, follows the System Supply section below.

High Voltage Power Supply

Two plug-in printed circuit boards, C22 and C27, form the high voltage power supply. The dual range supply is designed to

satisfy the most critical requirements of scintillation or proportional counting. Its complete solid-state design increases operational reliability in keeping with the latest trends in transistor circuit design. Basically, the supply is a DC-to-DC converter using a high gain feedback amplifier to control the desired output level, and provide required regulation. In the 1.5KV range the output voltage can be selected from 500 to 1490 volts in 100 or 10 volt increments by means of COARSE ADJUST and FINE ADJUST front panel controls. In the 3KV range the same controls permit selection of the output voltage from 1500 to 2985 volts in 150 or 15 volt increments.

For ease of maintenance and service, the power supply is mounted on two printed circuit boards which can be removed from the cabinet with minimum effort. A safety interlock is provided, disabling the supply whenever the front panel is lowered exposing any dangerous areas.

Board C22 contains the circuits associated with the regulator; board C27 houses the transformer, switches and filter circuits. Either board may be independently removed while the power switch is on provided the interlock is operational, and all high voltage has been removed from the circuit. Referring to Figure 3.2, high voltage is generated by alternately shorting each transformer leg to ground through switching transistors. The absolute value of high voltage is determined by the amount of DC applied to the center tap which, in turn, is determined by front panel selector settings.

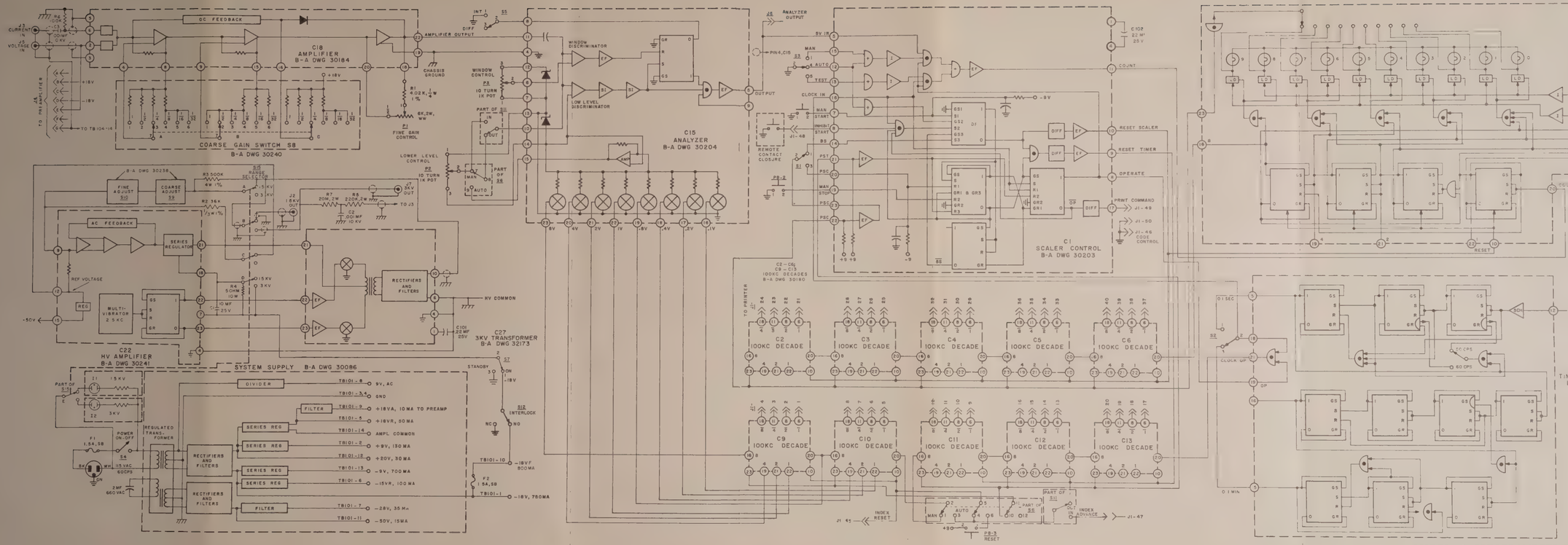
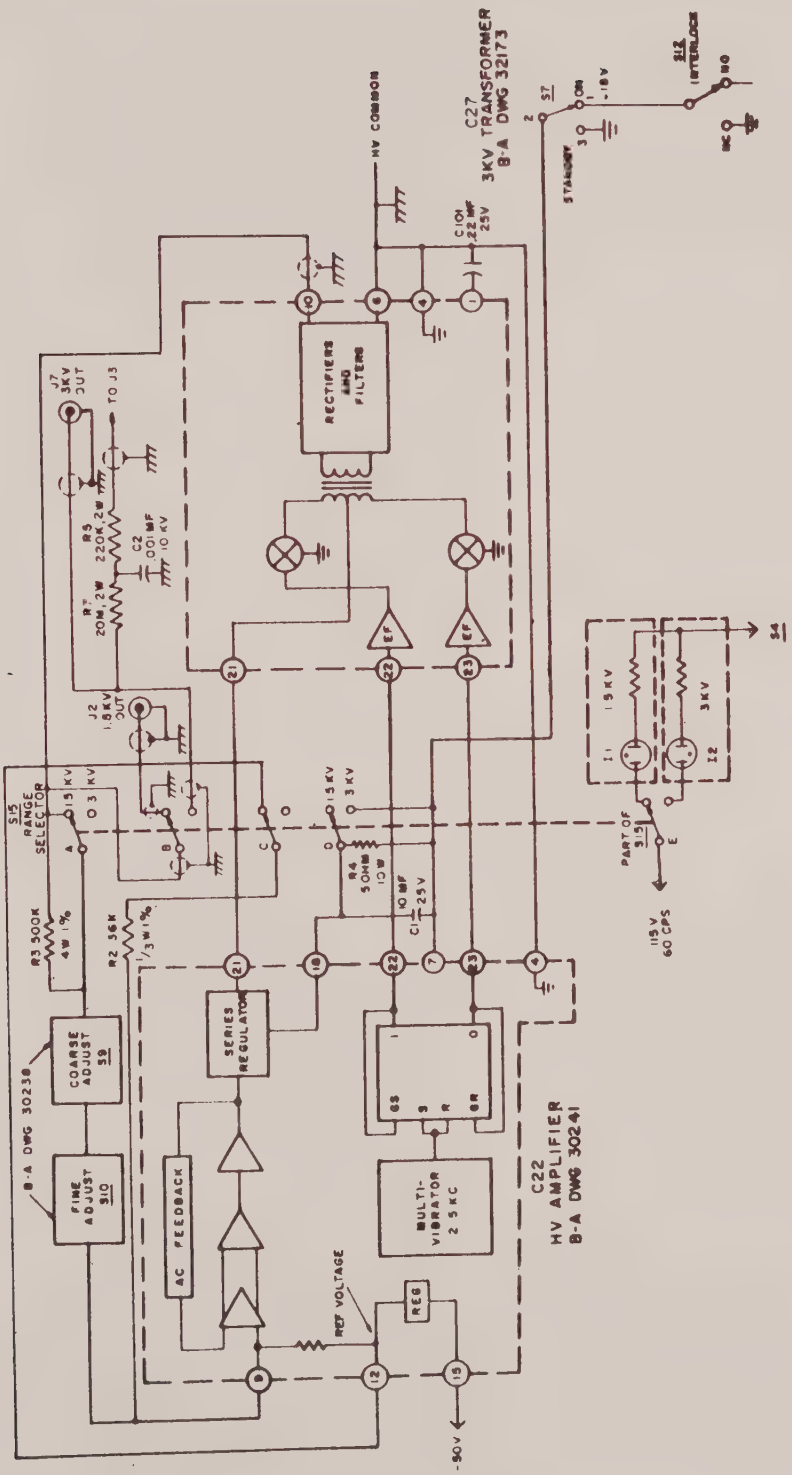

C18 AMPLIFIER B-A DWG 30184
DC FEEDBACK
COARSE GAIN SWITCH S8 B-A DWG 30240
FINE GAIN CONTROL
WINDOW DISCRIMINATOR
LOW LEVEL DISCRIMINATOR
C15 ANALYZER B-A DWG 30204
C1 SCALER CONTROL B-A DWG 30203
C7 IMC DECADE B-A DWG 30180
C2 100KC DECADE
C3 100KC DECADE
C4 100KC DECADE
C5 100KC DECADE
C6 100KC DECADE
C9 100KC DECADE
C10 100KC DECADE
C11 100KC DECADE
C12 100KC DECADE
C13 100KC DECADE
C8 TIMER COUNT DOWN B-A DWG 30181
C22 HV AMPLIFIER B-A DWG 30241
C27 3KV TRANSFORMER B-A DWG 32173
SYSTEM SUPPLY B-A DWG 30086
AC FEEDBACK
SERIES REGULATOR
MULTI-VIBRATOR 2.5KC
RECTIFIERS AND FILTERS
REF VOLTAGE
FINE ADJUST
COARSE ADJUST
DIVIDER
FILTER
SERIES REG
REGULATED TRANSFORMER
POWER ON-OFF
115 VAC 60CPS
STANDBY
INTERLOCK
REMOTE CONTACT CLOSURE
RESET SCALER
RESET TIMER
OPERATE
PRINT COMMAND
INDEX RESET
INDEX ADVANCE
50/60 CPS IN 9VAC
MODEL 530 SPECTROMETER LOGIC DIAGRAM

Figure 3.1



HIGH VOLTAGE POWER SUPPLY LOGIC DIAGRAM

Figure 3.2

An astable multivibrator generates a 2.5 kc signal and is coupled to a flip-flop which functions to produce a symmetrical drive to the transformer switches. In the process the drive frequency is reduced by a factory of two. A buffer stage, inserted between the flip-flop and switches, provides isolation; it also provides a path for leakage current on alternate cycles where the switching transistors are cut off.

To obtain the desired load regulation and stability, a highly efficient regulating circuit is employed to control input voltage to the DC-to-DC converter. A sampling of the output is compared with a zener reference voltage and the difference amplified and applied as a correction voltage to the converter transformer. The circuits may be discussed under five major loop elements -- sampling, reference, comparison, amplifier, and control.

The sampling element consists of 12 precision resistors mounted on the rear panel range and front panel coarse and fine adjust switches. These resistors form an accurate voltage divider with a resistor in series with the reference element. The reference element consists of two zener breakdown diodes in series, and constituting a stable 18 volt source. Two 9 volt units are used in preference to one 18 volt diode because of the better temperature coefficients obtainable with low voltage zeners.

The comparison element is a 6-terminal device containing two electrically identical, isolated transistors connected as a difference amplifier. By having the junctions of the two collectors physically close to one another, a difference in parameters with

temperature changes can be held to a minimum. The comparison amplifier, as the name implies, compares a portion of the high voltage output with the reference and produces an output proportional to the difference voltage. Since the comparator is referenced to ground, the input appears as a virtual ground.

Any tendency for the output voltage to vary other than in response to a change in sampling resistors will occur as an error signal to the comparator. The error is amplified and applied in correct phase to control the output. When the sampling resistors are changed, for example, if the operator desires to select a different output voltage, the regulator forces the output to a level where the sampling and reference resistors maintained the proper voltage divider ratio.

Comparator output, being insufficient in itself to properly correct for output errors, is coupled to a 2-stage DC amplifier before being applied to the control element. Total loop gain is sufficient to maintain the output within 0.01% for load changes of 5 ma. Because the DC loop encloses all critical parameters, the supply is quite stable over long periods of time.

The control element is a compound-connected series regulator which reacts to a change in base drive by making the necessary adjustments to transformer voltage. Any change in high voltage output is thereby corrected.

Beside the major DC feedback loop, a minor AC loop is connected from the output of the amplifier to the comparison element. The gain of the loop for 60 and 120 cycles is high enough to reduce

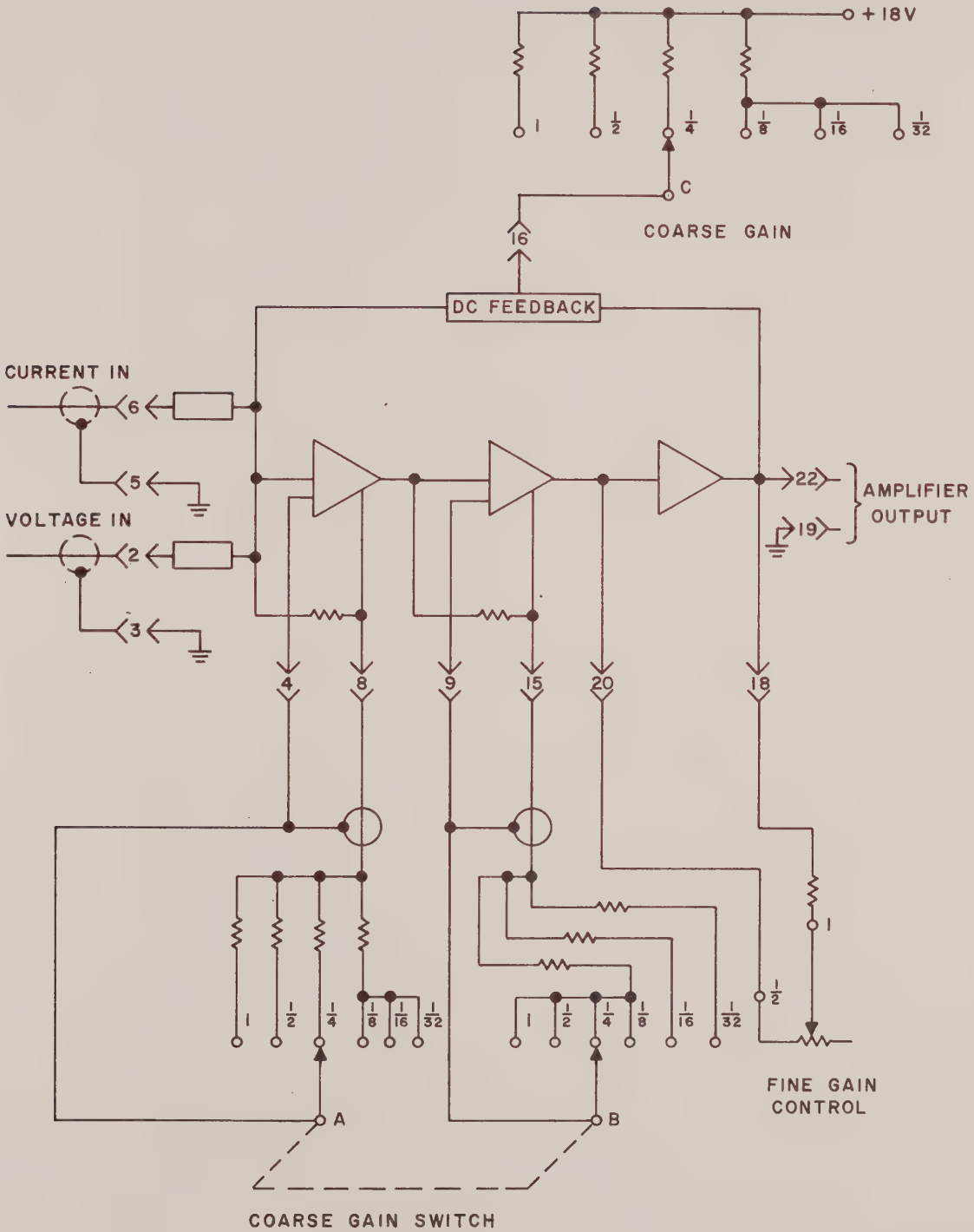
low frequency noise appearing at the output.

Were it not for the high voltage being within a strong DC feedback loop, the output load regulation would be in the order of 5% with an effective output resistance of 15,000 ohms. For stringent load regulation specification the loop must have a minimum gain of 500. To provide operation within specifications over operation life, all components are derated from manufacturer's specification; circuits are designed to operate efficiently with large changes in transistor parameters. With a minimum loop gain of 500, load regulation is held to 0.01% of maximum output. Output resistance is then approximately 30 ohms.

To decrease changes in high voltage with AC line variations, a well-regulated low voltage power supply is used as the source of input power. The power transformer provides 1% regulation of recitified output for a $\pm$10% change in line voltage. Additional regulation is employed where critical circuitry requires. Since the DC amplifiers are within a strong feedback loop, small changes in operating voltages are not critical.

Amplifier

The amplifier, a non-overloading type pulse amplifier contained on board C18, features exceptionally high and stable gain; it has both a current and voltage input for increased flexibility. As shown in Figure 3.3 the amplifier consists of three direct coupled stages connected with an overall DC feedback network to maintain operating point stability. Direct coupling



AMPLIFIER LOGIC DIAGRAM

Figure 3.3

eliminates the need for coupling and bypass capacitors which could cause severe recovery problems when the amplifier is subjected to a wide dynamic range of signals.

Gain of each stage is controlled by negative feedback loops to stabilize it against power supply variations and parameter drifts due to temperature and aging. Amplifier gain is varied by changing the resistors in the feedback loops; to reduce total effective shunting capacity, feedback resistors are located directly on the coarse gain switch.

The first stage consists of two doublet stages connected in a stabilized current gain configuration. Each doublet is comprised of a grounded emitter stage driving a grounded base stage in a complementary cascode arrangement. This configuration has proven advantages: high speed operation is enhanced due to the low impedance base to the emitter junction, shunting the high collector impedance, and effectively eliminating the Miller multiplication of base-to-collector capacity. As a further advantage, many such stages may be directly coupled with no "creeping up" of operating points normally encountered in other direct-coupled stages, since each stage can operate with zero volts in and zero volts out.

The second doublet stage is very similar to the first with negative current feedback employed around the two doublets to establish the stage gain. Maximum current gain of the first stage is 32, when the gain switch is in position 1; minimum gain is 4, when the gain switch is in 1/8, 1/16 and 1/32 positions. Frequency stabilization networks control the upper 3 db point of the stage. Stage bandwidth is about 3 mc.

Since the negative feedback is to the input terminal of the stage, the input impedance of the stage is very low, being equal to the feedback resistor divided by the loop gain of the stage. Typically, input impedance is about 25 ohms. There are two inputs to the amplifier -- current input, pin 6, and voltage input, pin 2. The current input is used directly with a phototube with no preamplifier required; voltage input is used in conjunction with low output impedance preamplifiers.

Input current is amplified in the first stage and passed to the second stage through the grounded base of the second doublet transistor. The second stage is also a current gain stage identical in operation with the first stage. Stage two gain is varied from 32 to 8, and the bandwidth is also about 3 mc.

The third stage consists of a doublet and a complementary emitter follower section connected as a current-to-voltage transfer stage. The amplified input current, coupled into the third stage, flows through the feedback resistance connected between pins 20 and 18. Feedback resistance consists of 4.99 k resistor in series with the fine gain control, and a 5000 ohm wirewound, one-turn potentiometer mounted on the front panel. Frequency stabilized networks set the stage bandwidth at about 2 mc.

The output of the amplifier, pin 22, is in the form of a voltage pulse. Dynamic output impedance of the complementary emitter follower is low, nominally less than 10 ohms. A major DC feedback network maintains desired operating points within the amplifier. The maximum high frequency amplifier gain, equal to the DC gain if no DC feedback is employed, is 10 volts per microampere.

For example, a one microampere change in base current in the first stage would cause a 10 volt change at the output. The

major feedback loop reduces this sensitivity at DC by a factor of 3000. A one microampere DC change in base current in the first stage changes the output by only 3 mv.

Maximum amplifier gain of the amplifier is 1000, referring to the voltage input, and 10 volts per microampere, referring to the current input. Gain may be reduced by factors of two with the COARSE GAIN control to a minimum of 1/32 of the maximum. The FINE GAIN control allows continuous adjustment over a 2 to 1 range. This permits the gain of the amplifier to be set anywhere from 16 to 1000.

Amplifier linear range output is about 15 volts, or approximately 50% over analyzer input range.

Analyzer

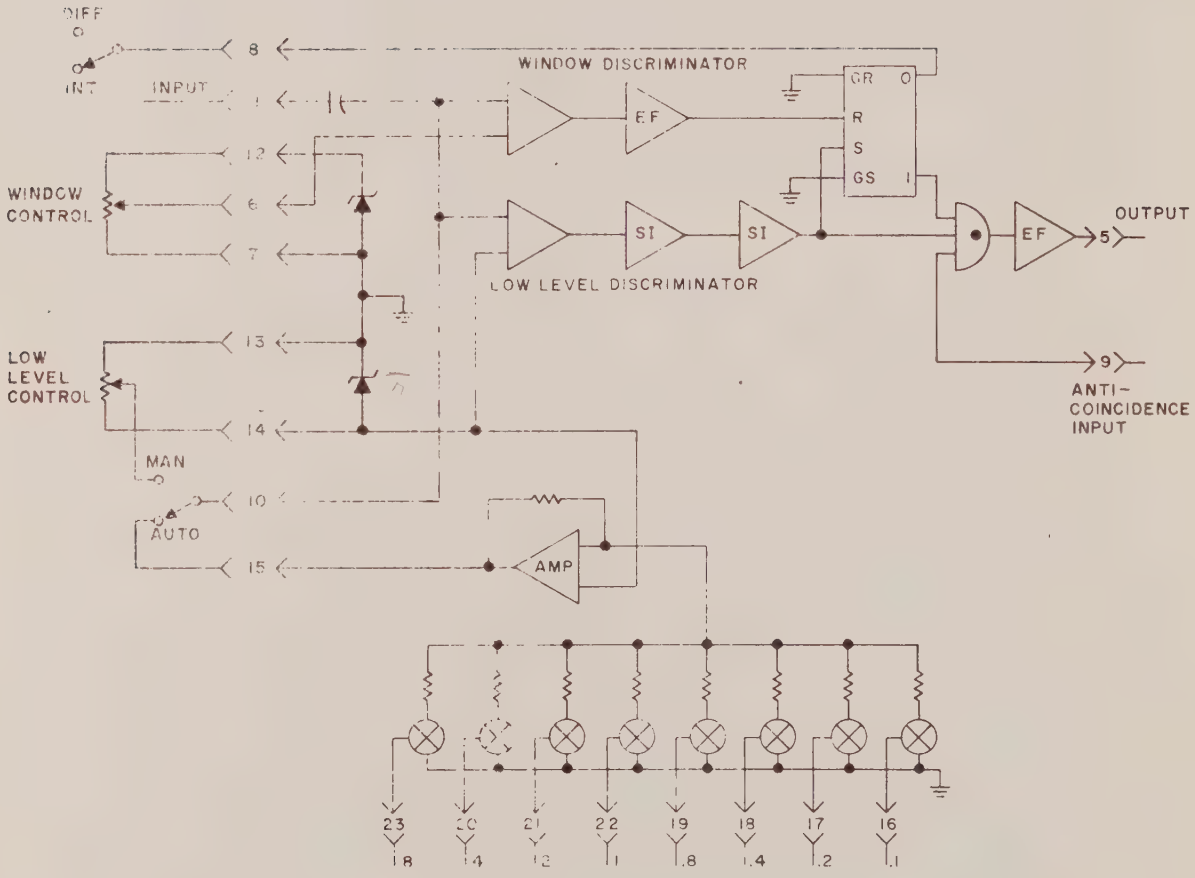
Figure 3.4 graphically illustrates the single channel pulse height analyzer contained on board C15. The analyzer consists of a lower level discriminator, a window discriminator, pulse shaping circuits, coincidence gating, and a digital-to-analog converter for automatically advancing the baseline.

The input pulse is fed into both discriminators which have zero gain until the threshold is exceeded, after which the gain is quite large. If the pulse exceeds the lower level threshold, a positive pulse appears at the discriminator output. The negative-going trailing edge of the pulse is differentiated and shaped by two shaping inverters. The second inverter has a negative going pulse about 7 volts in amplitude, and about 0.5 microsecond in width. If the window threshold is not exceeded, the diode gate will be in the enabled state (negative level) and the pulse will also appear at the output, pin 5, after passing through a complementary emitter follower used for capacity buffering.

If the input pulse exceeds the window threshold as well as the lower level threshold, then a positive pulse also appears at the output of the window discriminator. The pulse passes through an emitter follower and the leading edge of the pulse drives the flip-flop to the reset condition which places the diode gate in its inhibit state. The pulse caused by differentiating the trailing edge of the lower level discriminator output will then be prevented from passing through the diode gate. Under this condition no output pulse will appear at pin 5.

The collector of the flip-flop transistor is brought out through pin 8 to the INT-DIFF front panel switch where it is grounded in INT operation. Grounding the flip-flop keeps it in the set condition. Every pulse which then exceeds the LOWER LEVEL setting appears as an output pulse whether it also exceeds the WINDOW setting or not.

The use of the flip-flop as the gating element for the window discriminator has several advantages. First, it provides a custom-tailored inhibiting signal if the upper level as well as lower level discriminator is exceeded. The inhibit signal at the output gate is set up during the leading edge of the pulse. The inhibit level is not removed until after the pulse which is being inhibited expires, for the pulse trailing edge is used to return the flip-flop to its enabled state. The lower level pulse may occur any time during the decay time of the input signal, determined by the relative position of the lower level discriminator to the height of the pulse. The inhibit signal will vary in width depending upon how much the input pulse exceeds the threshold. Resolving time is fast while guaranteeing that erroneous pulses will not be passed because they are wider than anticipated; there is no need, too, for adjusting a "resolving time" control which changes a fixed inhibiting



ANALYZER LOGIC DIAGRAM

Figure 3.4

level width in finite increments. Last, there is no need for costly and bulky shaping techniques -- delay line differentiation required with some analyzers to give a precise pulse width so the circuits will function during overload. With the Baird Atomic analyzer, wide pulses that occur during amplifier overload are handled like linear pulses.

The lower level discrimination level may be set manually with a 10-turn precision potentiometer, or automatically by the digital-to-analog converter. Window discrimination is always established by the WINDOW 10-turn precision potentiometer.

The lower level discrimination is performed in a differential discriminator, the base of which is referenced at about -0.7 volt, and brought out to the MAN-AUTO switch. The front panel turning dial of the 10-turn potentiometer is calibrated in per cent of full scale; extreme precision in setting may be accomplished since the smallest graduations on the dial are in 0.1% increments. The LOWER LEVEL setting establishes the reverse bias on the base-to-emitter junction. A factory adjustment nulls out an initial base-to-emitter junction drop so that zero bias exists when the potentiometer is set at zero. With no pulse present at the analyzer input, pin 11, part of the lower level discriminator is fully conducting, the other part off. When an input pulse exceeds the reverse bias set by the LOWER LEVEL control, the part off starts to conduct, taking a portion of the 3.5 ma available from the current source away from the part conducting, the collector of which rises toward +18 volts. The positive rise is coupled back to the base of the part starting to conduct to give a small amount of positive feedback which increases the discriminator gain and speed. Average gain from the input to the collector is about 500 as the discriminator passes from non-conduction to full conduction.

The window discriminator is similar in operation to the lower level discriminator. Since the base of the lower level discriminator is connected to the LOWER LEVEL control, through pin 10, it can vary between zero volts and -9 volts. The WINDOW setting, which can be varied between zero and +9 volts, always rides on top of the LOWER LEVEL control and is never independent of it. The setting of the WINDOW control is from zero to 100% of full scale. However, the linear range is determined by the amplifier that precedes it. Since the full scale range of the analyzer is 9 volts, and that of the amplifier 15 volts, maximum WINDOW setting for linear operation at any baseline setting, including 100%, is 50%. When operating with less than 100% baseline, the difference may be applied to the WINDOW setting. For example, if the LOWER LEVEL is set for 50% or less, the WINDOW setting may go up to 100%.

When the analyzer mode switch is moved from MAN to AUTO, the front panel LOWER LEVEL control is disconnected from the discriminator and the digital-to-analog converter is switched in. DAC amplifier low impedance is brought out on pin 15 and switched into pin 10 as the lower level bias voltage for both discriminators. Control signals, generated from the outputs of two binary-coded decimal decade counters operating between the logic levels of zero volts for binary zero to -6 volts for binary one, are brought in on pins 16 to 23 for the eight switches. The switches control binary-coded decimal-weighted resistors which determine the amount of current flowing into the DAC amplifier input summing point; amplifier output voltage is proportional to the input summing point current.

Counters used for controlling the DAC switches in AUTO are the two most significant digits of the 5 decade timer during the MAN operation. The counters, Figure 3.1, advance by one

count each time the scaler-timer is started, thereby advancing the baseline by one channel or 1%, each time. The baseline stays at that setting until the scaler-timer is stopped and then started again. The automatic baseline feature automatically sweeps the lower level discriminator through its full range in 1% increments, permitting a complete spectrum to be gathered and automatically printed.

Scaler-Timer

The scaler-timer consists of a 6-decade 1 microsecond resolving time scaler and a 5-decade timer. Each digit of every decade is presettable by means of front panel accessible, thumbwheel switches. The scaler-timer contains a background subtract feature as well as an automatic operation mode. The 4 line outputs of all eleven decades are designed to operate directly into a parallel printer such as the Baird Atomic Model 610 Printer (see Chapter 1) which prints out at 3 lines per second maximum.

Physically, the scaler-timer is constructed on 13 printed circuit boards. The scaler control board, C1, (Figure 3.1) contains all control logic for starting, resetting and stopping the scaler-timer. The board also contains the background subtract and printer command circuits. The six decades of the scaler are located in card positions C2 to C7. Each decade board is complete within itself, containing the 10-lamp incandescent readout display and 10-position thumbwheel switch, as well as a four-stage flip-flop counter. The least significant digit of the scaler, C7, is a 1 mc decade board. The other decades, C2 to C6, are 100 kc decade boards.

The timer countdown board, C8, contains the flip-flop counters which divide down the 60 cps power signal to a 0.1 second

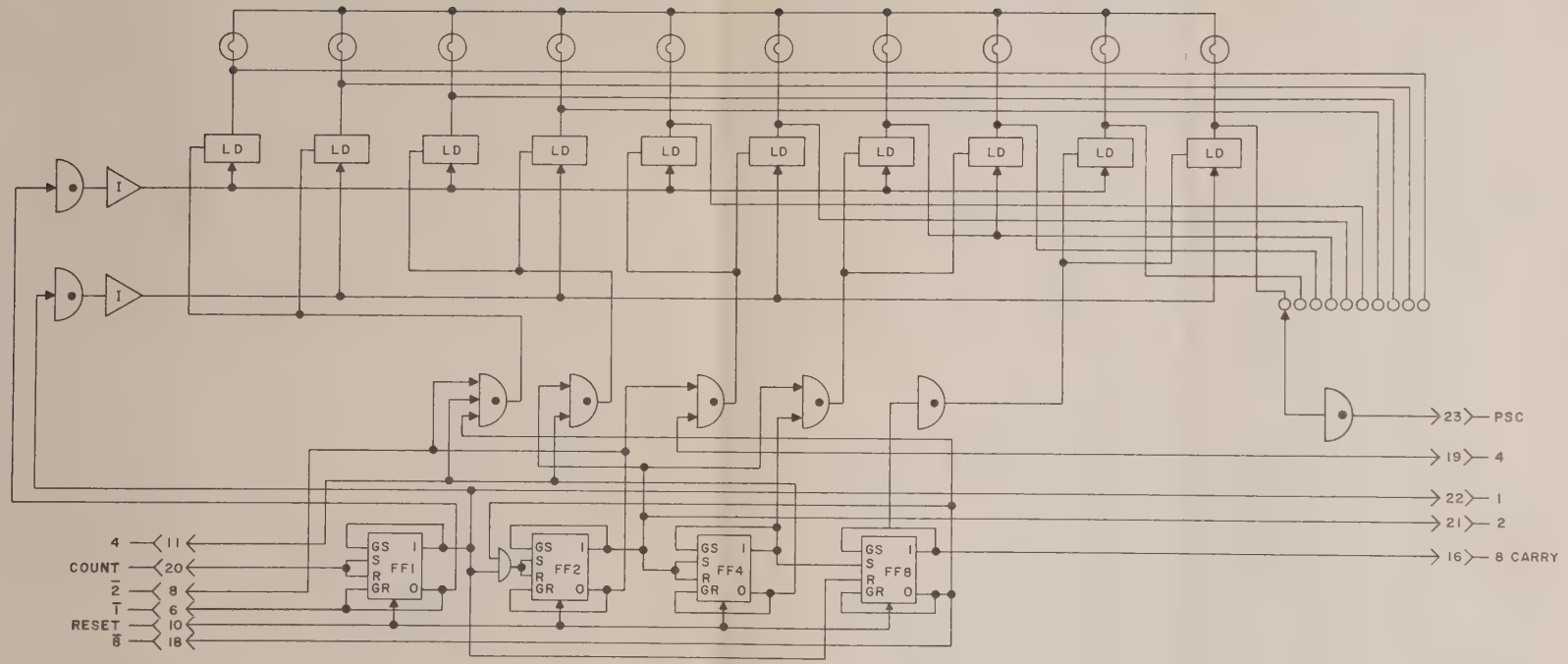
and 0.1 minute signal, either of which is selectable as the timer time base. Card positions C9 to C13 contain 100 kc decade boards for the five decades of the timer. These five boards are identical and interchangeable with the five 100 kc decade boards used in the scaler. When the automatic baseline feature of the analyzer is employed, the decades in C9 and C10 are used to count channel numbers rather than indicating the two most significant digits of the timer.

100 kc Decade Counter

The 100 kc decade counter shown in Figure 3.5 contains a four-stage binary-coded decimal counter, a BCD-to-decimal converter, 10 lamp drivers and lamp, and a 10-position thumbwheel switch.

The counter consists of four flip-flops connected to give a 1-2-4-8 BCD code output. A BCD counter differs from a straight four-stage binary counter in that the counter recycles after 10 input pulses rather than 16 pulses. The counter starts in a reset condition of zero. As each input pulse comes in, the count advances from zero to nine in normal binary fashion. However, the tenth input pulse restores the count to zero rather than to ten. Since negative logic is employed, a flip-flop is in the ONE or set state when the ONE output is negative; it is in the ZERO or reset state when the ONE output is at ground. A flip-flop changes states when its input changes from a ONE to a ZERO state. The negative level is normally -6 volts $\pm$ 1; the zero outputs of the decade are -10 volts $\pm$ 2 to be compatible with the printer that it drives.

As Figure 3.6 shows, the relative timing of the four stages is identical to that of the first ten states of a four-stage binary counter. The BCD counter is implemented in the following manner:

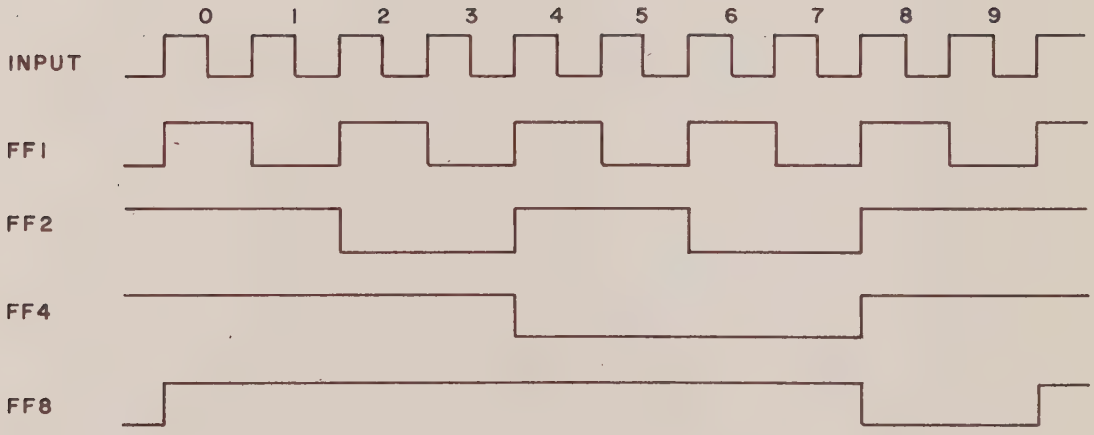


100 kc and 1 mc DECADE COUNTER
Figure 3.5

FF1 is complemented by the input signal coming in on pin 20. FF1 then drives the complement input of FF2 through the AND gate. $\overline{FF8}$ remains in the enabled condition until the eighth input pulse is received. FF2 changes states when the second, fourth, sixth, and eighth pulses arrive. Since $\overline{FF8}$ is in the inhibit condition from the time the eighth pulse is counted until the tenth pulse, FF1 being prevented from coupling when the tenth pulse arrives, FF2 is inhibited from changing states. After the tenth pulse, FF2 and FF1 are in the reset condition. FF2 drives directly into the complement input of FF4. Since FF2 is reset from the ONE state to the ZERO state with the fourth and eighth pulses, FF4 is set with the fourth pulse and reset with the eighth pulse. FF4 drives the set input of FF8. When FF4 goes positive on the eighth pulse, FF8 is driven to the set state. FF8 is returned to the reset state by FF1 when the tenth pulse arrives. Therefore, after the tenth pulse, all four flip-flops are in the reset condition, ready to start the count of ten again. The output of FF8 is taken out through pin 16 to connect to the input of the next decade. The outputs of the ZERO sides of the flip-flops (used since positive logic is employed) are taken out on pins 6, 8, 11 and 18 to drive a parallel printer.

The direct reset input is brought in on pin 10. When a positive pulse appears at pin 10, all flip-flops are forced to a reset condition.

Incandescent lamps indicate the state of the counter at any instant. Lamp DS101 lights up numeral 0, DS102 lights up numeral 1, and so forth. Emitters of the even numeral drivers are connected together; emitters of the odd numeral drivers are also connected together but separately from the even numerals.



BCD COUNTER TIMING DIAGRAM
Figure 3.6

Multiple use is made of the decoding done for the lamps. The output of each driver connects to one of ten positions of the thumbwheel switch mounted on the board. The switches are used for presetting a count on the scaler or timer. When the count is reached corresponding to the setting of the switch, the cathode of the decade diode is driven positive. The anode of the diode is brought out to pin 23 where it is wired to the anodes of similar diodes in other decades, forming a positive AND gate. When the count is reached in each decade corresponding to the switch setting in that decade, a positive going pulse occurs at the output of the gate, which is then used for stopping the counting operation.

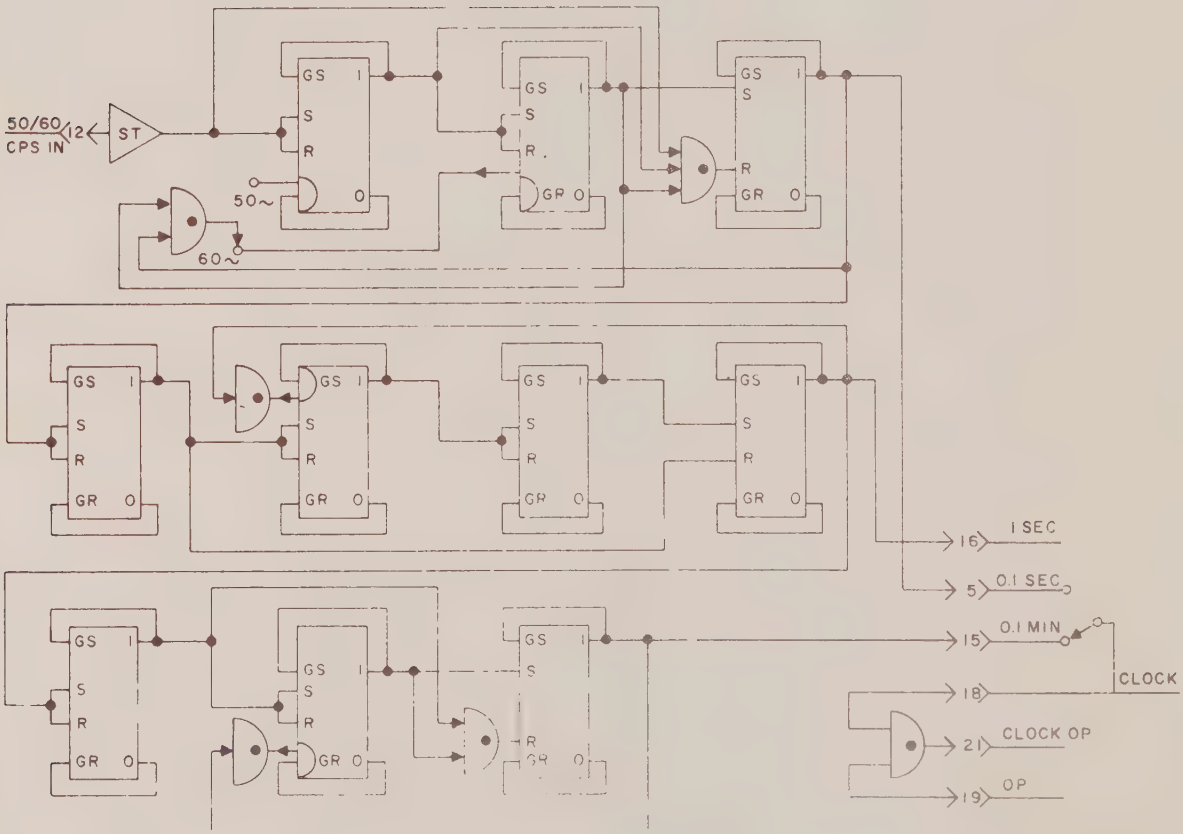
1 mc Decade Counter

A higher speed flip-flop is used in the 1 mc decade counter. Figure 3.5 shows a detailed logic diagram.

Timer Countdown

A timer countdown board shown in Figure 3.7 generates a clock signal used as a time base for the scaler-timer. Line frequency is used as the input signal source. The 60 cps sine wave is shaped in a Schmitt trigger and then frequency-divided by six (Figure 3.8) to generate a clock signal at pin 5 which occurs at a 10 cps rate or a 0.1 second period. The 10 cps signal is then divided by ten to give a 1 second clock at pin 16. The signal is further divided down by a factor of six presenting a 0.1 minute clock at pin 15.

Either the 0.1 second or the 0.1 minute signal is selected by the front panel 0.1 SEC - 0.1 MIN 2-position switch. The selected clock signal is gated with the operate (OP) signal before being applied to the input of the least significant digit of the timer.



TIMING COUNTDOWN LOGIC DIAGRAM

Figure 3.7

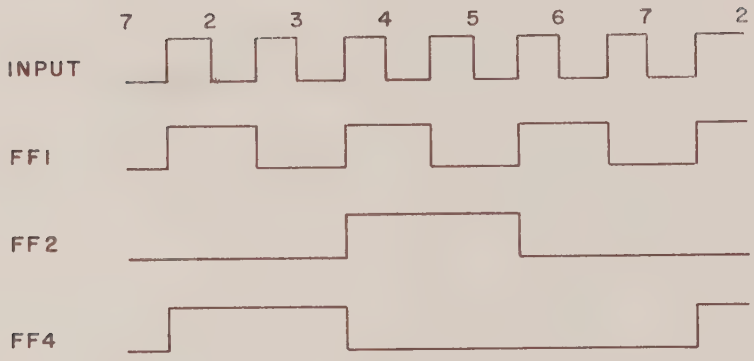
If the equipment is connected to a 50 cps power source, the first counter can easily be changed to a divide-by-five (Figure 3.9) rather than six by moving one jumper on the board.

The 9 volt peak-to-peak 60 cps sine wave is connected through pin 12 to the Schmitt trigger which squares up the signal and establishes the proper signal levels. The divide-by-six consists of a three-stage flip-flop counter accomplished by resetting to the complement of the total count capacity desired rather than resetting to zero.

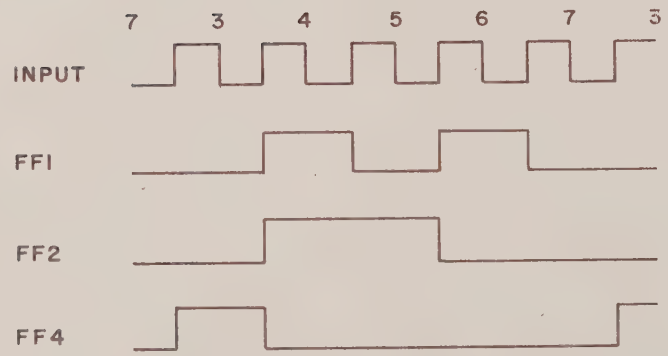
The counter starts off with a ZERO in the first and third flip-flops, a ONE in the second. The first flip-flop, FF1, complements with the output of the Schmitt trigger; the second, FF2, complements from FF1. FF2 resets with the second pulse and sets with the fourth, but is inhibited from resetting when the sixth pulse comes in. Since the third flip-flop, FF4, is set by FF2, it goes to the set state with the second input pulse and stays set until FF4 is reset with the sixth input pulse. The counter then starts off with a count of two, counts to seven, and then repeats.

When a 50 cps source is used jumper A to B (60 cps power source) is changed to A to C which causes the counter to reset to a count of three rather than two. In the divide-by-five counter, FF1 is inhibited from resetting after the fifth pulse, or when the counter is in state 7. If FF1 does not reset, FF2 remains set; FF4 is reset with the first pulse causing the counter to go from state 7 to 3.

The first counter output contains one pulse every 0.1 second. The second counter is a four-stage binary-coded decimal which divides by ten -- gives one pulse out for every ten input pulses to it. BCD counter output, pin 16, consists of a pulse every one second which drives another operationally similar divide-by-six counter.



DIVIDE-BY-SIX TIMING DIAGRAM
Figure 3.8



DIVIDE-BY-FIVE TIMING DIAGRAM
Figure 3.9

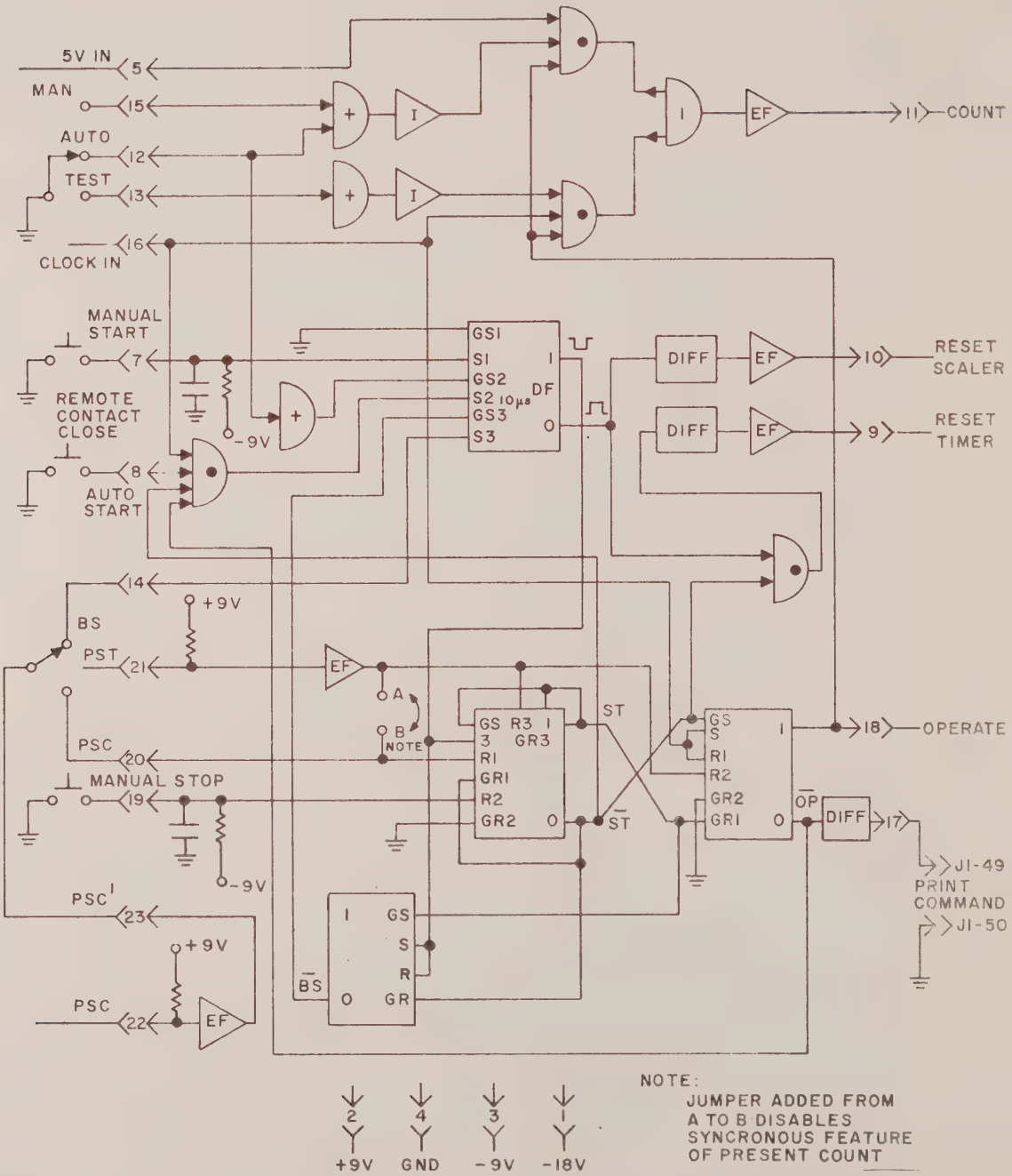
Scaler Control

The scaler control board, Figure 3.10, generates printer command signals, contains background subtract circuits, and all circuits for starting, stopping, and resetting the scaler-timer.

The output from the analyzer (Figure 3.1) feeds into the 5 volt input, pin 5, passes through some gating and comes out at pin 11 to drive the first scaler decade. The gating of the analyzer signal is under control of the OP flip-flop which also controls the application of the clock signal to the timer decades.

When the mode switch is set to MAN or AUTO, either pin 15 or pin 12 is grounded, causing the inverter output to go negative. When the mode switch is in the TEST position, the converse is true -- the clock signal is applied to the scaler as a test input.

The start function is accomplished by pressing the START pushbutton when in the MAN mode; it is automatically accomplished when in AUTO. The start operation is always synchronized to the timer clock and always provides a reset pulse to the scaler and timer first. When the START button is pressed a pulse at pin 7 triggers the delay flop which gives out a positive going 10 microsecond pulse from its ZERO side, and a negative going pulse from its ONE side. The leading edge of the positive pulse is differentiated and passes through an emitter follower to pin 10 to reset the scaler. The positive pulse also passes through a gate which is enabled when the scaler is in the STOP position, on through a differentiator and emitter follower to pin 9 to reset the timer.



SCALER CONTROL LOGIC DIAGRAM

Figure 3.10

The trailing edge of the 10 microsecond negative pulse from the delay flop drives the set input of the start (ST) flip-flop, used for synchronizing the start of scaler operation with that of the timer. ST and $\overline{ST}$ signals condition the gate set and gate reset inputs of the OP flip-flop, allowing the next clock that occurs to set it. The OP signal goes negative, conditions the count gates, and allows either the analyzer signal or the test signal to drive the count input of the scaler. The OP signal also goes to the timer countdown board where it enables the clock to drive the timer.

When the mode switch is in AUTO, GS2, another gate set input of the delay flop is enabled, allowing the S2 input to trigger it. The S2 input is driven by a gate which is connected to the clock signal, pin 16; the gate is enabled when the ST and OP flip-flop are in the stop state. Another input to the gate at pin 8 allows an external device to control the starting function. When the printer is employed an "inhibit start" signal, consisting of contact closure to ground, prevents the start function while the printer is getting set to print. Once the printer does not require the data inputs any longer, the contacts open, enabling the gate which allows the next clock signal to pass and trigger the delay flop. Then the signal at pin 8 behaves as an inhibiting rather than a triggering function.

In any mode of operation the counting cycle may be stopped in one of three ways -- manually, preset time (PST), or preset count (PSC). Each of the methods is an overriding type, stopping the count if it occurs before any of the others. When the STOP pushbutton is pressed, the ST flip-flop is reset, conditioning the OP flip-flop to reset on the next clock pulse. Once the OP flip-flop resets, the counting stops.

For PST stop, when the timer reaches the number preset on its thumbwheel switches, a positive pulse appears at pin 21, passes through an emitter follower, and resets both the ST and OP flip-flops. The scaler control board is normally provided with synchronous PSC. When the scaler count reaches the number preset on the scaler thumbwheel switches a positive pulse appears at pin 22 and passes through the emitter follower to pin 23. It then goes through the preset count - background subtract (PSC - BS) switch.

In the PSC position, the signal re-enters the scaler control board through pin 20 and resets the ST flip-flop. The stop is synchronized since the OP flip-flop does not reset until the next clock pulse. Meanwhile until the clock arrives, the scaler is allowed to accumulate counts over and above the number preset on the scaler. When the next clock arrives, the OP flip-flop resets, stopping the count. The total count displayed in the scaler, then, is the exact number of counts which occurred in the time interval displayed in the timer.

Some users prefer to stop the count non-synchronously on the exact count preset, so provision has been made to disable the synchronous feature. By adding a jumper, as shown on Figure 3.10, between points A and B in the scaler control board, the scaler will be in the non-synchronous preset count state.

The OP signal is differentiated and brought out to pin 17 as the print command signal. Whenever the scaler is stopped the printer receives the print command signal, a 15 volt negative going pulse with a 40 millisecond decay time, to initiate the print cycle.

When the PSC - BS switch is in the BS position, the PSC signal, generated when the scaler reaches the number set in the scaler thumbwheel switches, is directed via pin 14 to the delay flop which triggers resetting the scaler. However, no reset timer pulse occurs since the delay flop signal is gated with the $\overline{ST}$ signal to generate a reset timer pulse. Since the $\overline{ST}$ is in the set state when the scaler is running, $\overline{ST}$ will be at ground, inhibiting the gate and blocking the reset timer pulse. Only the scaler then, and not the timer resets when the preset number is reached and the count continues.

The delay flop signal also drives the flip-flop marked $\overline{BS}$, used to control the application of the preset signal to the delay flop. When the scaler is stopped, the ST flip-flop is in such a state as to condition the gate set of the $\overline{BS}$ flip-flop. $\overline{BS}$ goes to ground, enabling the gate set input GS3 of the delay flop. When the scaler reaches the preset background count it pulses the S3 input of the delay flop, triggering it.

This particular pulse also drives the $\overline{BS}$ signal to -6 volts, and thereby inhibiting the GS3 input to the delap flop. The next time the scaler reaches the background count it is prevented from triggering the delay flop. The count then continues and stops only on commands derived from setting the PST or MAN controls.

System Supply

The system supply as shown in Figure 3.1 is designed to provide reliable spectrometer operation over a wide range of line conditions. Using a constant voltage ferroresonant transformer, the power supply offers fast line regulation,

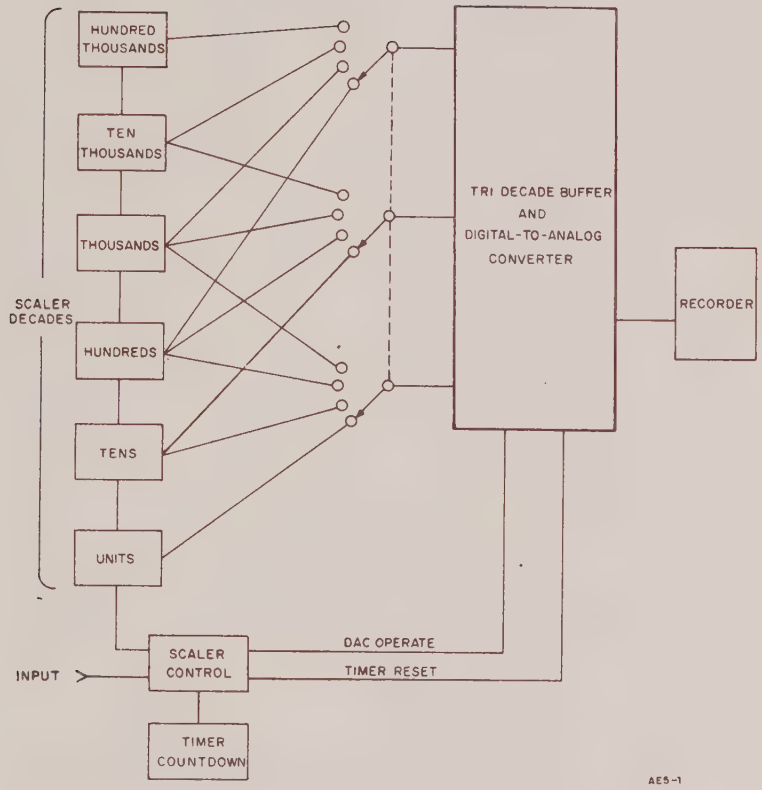
short circuit protection, automatic current limiting and increased circuit reliability. This type of system supply need only be followed by additional regulations where most critical circuit operation is required.

The basic supply consists of a full wave capacitor input circuit. The transformer, a constant voltage device, provides for 1% regulation of the raw supply over all normal line variations. For those circuits requiring a higher degree of regulation and isolation, additional regulators have been incorporated to provide -15, -9, +9, and +18 volts. These series regulators are emitter followers whose output voltage is maintained substantially constant. A divider provides a 9 volt signal referenced from the line used as the timing pulse for the scaler control. A separate winding provides an additional regulated voltage rectified and filtered to produce a -50 volt supply.

Digital-to-Analog Converter

The DAC printed circuit board, which plugs into card position C14, is a combination triple decade buffer storage register and digital-to-analog converter. The system (Figure 3.11) is designed to accept the 1-2-4-8 binary coded decimal (BCD) logic from any three adjacent scaler decades on command from the scaler control board at the end of a preset counting run.

Upon reaching a preset time, the scaler will stop counting and charge up the DAC input capacitors. On the next timing mark, because the spectrometer remote start line is not inhibited, the scaler-timer will receive a start command which triggers a delay flop. The scaler-timer and the DAC board are reset at the start of the delay flop period, and the DAC board receives a read command at the end of the delay flop period.



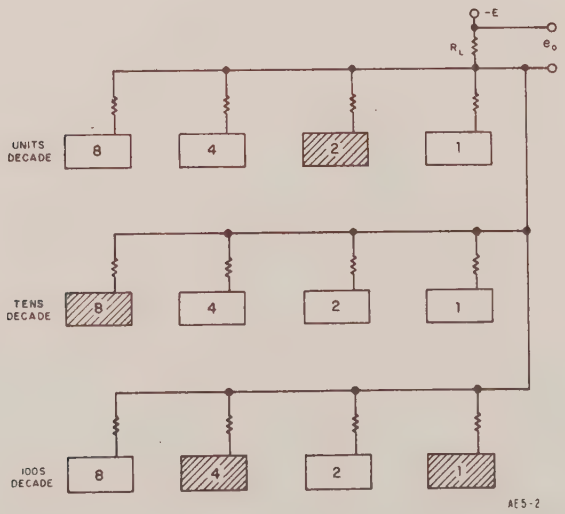
PARTIAL BLOCK DIAGRAM OF MODEL 530 SPECTROMETER SHOWING DAC SECTION

Figure 3.11

Since the time constant of the DAC input network is much longer than the delay flop period, only a very small portion of the charge on the capacitor is lost and each of the register flip-flops which is properly biased by an active decade line will trigger. The DAC card is actually a buffer register consisting of three binary coded decades that serve as memory elements for the three most significant decade positions being counted. These must be determined

prior to recording serious data by making a few trial runs, at which time the preset time and recorder speed are selected.

The analog signal is developed across the output resistors by a set of properly weighted precision resistors serving as the load resistors in each of the normally OFF sides of the register decade flip-flops. The scheme used to obtain the correct analog output is shown in Figure 3.12, where the ON flip-flops are shown shaded. The ON flip-flops are binary flip-flop 2 in the units decade, binary flip-flop 8 in the tens decade, and binary flip-flops 1 and 4 in the 100s decade. Since binary flip-flops 1 and 4 are in the 100s column, they must have a combined weight equal to 50% of the total current for full scale recorder reading in R_L. Binary 8 in the tens column adds 8% and binary 2 in the units decade brings



BLOCK DIAGRAM SHOWING HOW ANALOG VOLTAGE IS DEVELOPED

Figure 3.12

the total output current in R_L to 58.2% of full scale. Depending upon the output connections, this reading could be represented as either 58.2 millivolts or 0.582 milliampere.

The time interval selection covers the very broad range of 0.1 second or minute to 9999.9 seconds or minutes in increments of either 0.1 second or 0.1 minute, allowing "fine tuning" as it were of the total counts accumulated per time interval. The counting rate is easily established by a simple computation of counts divided by the time interval selected. In the channel advance mode the maximum time interval available is 99.9 seconds or minutes.

The x output on the rear terminal strip is provided to drive the x-axis of an x-y recorder. This output, presented as a step voltage consisting of 99 equal increments, ranges from approximately 0.9 volt to 9.7 volts negative. Since the output signal is taken from the same circuits which drive the spectrometer baseline in the AUTO mode, information pertaining to the channel advance (see Chapter 2, General Operating Procedures) applies also to the x-drive.

It is possible to use a 10 millivolt recorder to permit scale expansion. One technique is to shunt the 100 ohm resistor with a second 100 ohm resistor so twice the normal full scale DAC current is required to drive a 100 millivolt recorder to full scale.

If a 10 millivolt recorder is connected across the DAC output, a full count of the two least significant decades can be used to drive the recorder to mid-scale. Twice the overflow will be required to drive the recorder to full scale.

CHAPTER
4

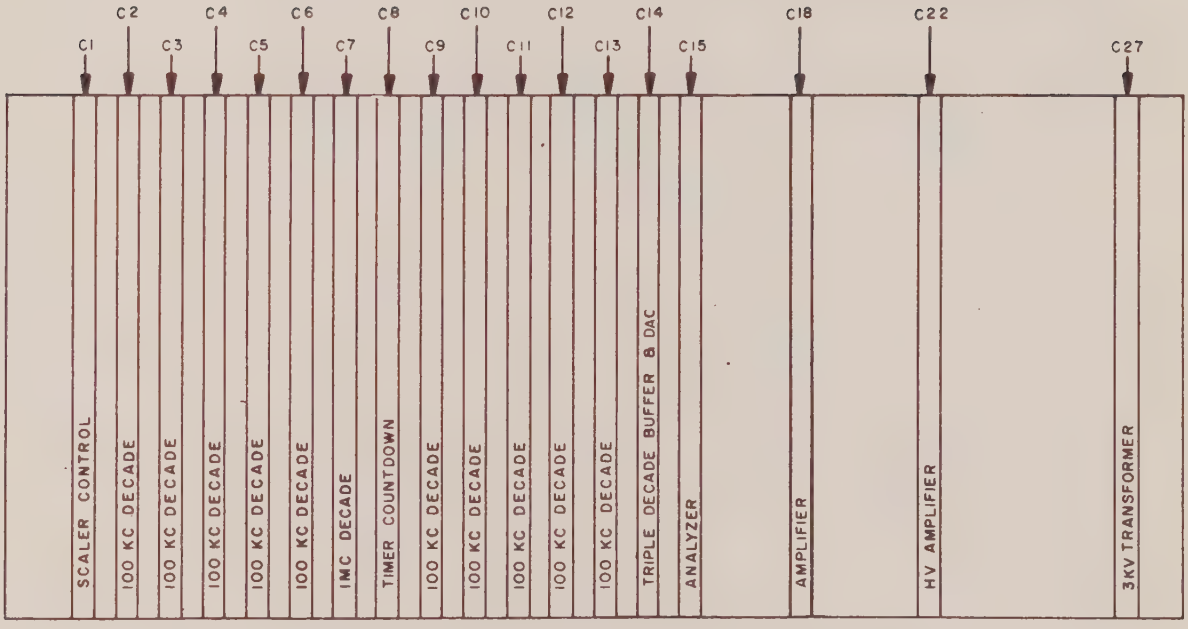
TROUBLESHOOTING

The spectrometer is constructed so troubleshooting can be performed without removing the card cage from its cabinet or the cabinet from the rack, if rack mounted. Card locations are shown in Figure 4.1.

All printed circuit boards are accessible from the front merely by lowering the hinged front panel. The boards may then be easily extracted by hand. Extender boards which plug into any of the connectors are available; the extender boards have a 23-pin female connector mounted on the edge closest to the front panel to accommodate any of the printed circuit boards, allowing work on the board while it is still connected.

Take precautions when the front panel is opened, for the high voltage is brought out to the COARSE ADJUST switch mounted on the front panel. Leave the red plastic protective can on the switch, and never insert or extract boards while power is on. All points that may be subjected to high voltage are in the right half of the spectrometer, but high voltage may be present on the amplifier board if the amplifier current input is being used. Always be doubly careful when the amplifier board is put on an extender.

Scaler-timer troubleshooting is easily performed since 10 or the 13 boards used, the 100 kc decade boards, are identical



SPECTROMETER PRINTED CIRCUIT BOARDS,
FRONT VIEW

Figure 4.1

and may be interchanged at random. One may troubleshoot by substitution, then, in the area of the 100 kc decade counter. A TEST mode is included in the scaler TEST mode for checking purposes and can be a valuable aid in troubleshooting. In TEST the clock base for the timer is inserted as the input to the scaler, allowing the scaler to be checked out with a steady signal applied.

Since the analyzer has two modes of operation, one means of troubleshooting here is by comparing results between the MAN and AUTO baseline modes.

Refer to Chapter 3 and the logic diagrams included in it to isolate and clarify any technical problems. If trouble in the spectrometer cannot be located and repaired, contact the nearest Baird Atomic office.

CHAPTER
5

PARTS LIST

All Model 530 Spectrometer components are fully identified in order to make possible procurement of replacements. Reference designations in the series from 1 through 99 appear schematically on the spectrometer logic diagram Figure 3.1; reference designations in the series from 100 through 199 and 200 through 299 appear schematically on Baird Atomic drawings 30238 and 30240 respectively which are included with this manual. The reference designations identify electrical/electronic component parts referenced in drawings or the text of this manual; mechanical parts which are not likely to require replacement during normal spectrometer service life are not assigned reference designations or included in this parts list.

For easy location all items given a reference designation in the parts list are arranged in alpha-numerical order. Exact spectrometer panel stamping, when it exists, is reproduced as part of the name of component and description column. Those few items listed without an assigned reference designation are included last in alphabetical order.

A parts list for the digital-to-analog converter immediately follows the spectrometer parts list.

MODEL 530 SPECTROMETER PARTS LIST

REF. DESIG.	NAME OF COMPONENT AND DESCRIPTION	PART NUMBER
C1	Capacitor, 10 mf, 25 volts	20938
C2 and C3	Capacitor, 0.001 mf, 10 kv	00476
C102 and C102	Capacitor, 0.22 mf, 25 volts	30318
C1	Scaler control board	30277
C2	100 kc decade board	30306
C3	100 kc decade board	30306
C4	100 kc decade board	30306
C5	100 kc decade board	30306
C6	100 kc decade board	30306
C7	1 mc decade board	30202
C8	Timer countdown board	30188
C9	100 kc decade board	30306
C10	100 kc decade board	30306
C11	100 kc decade board	30306
C12	100 kc decade board	30306
C13	100 kc decade board	30306
C15	Analyzer board	30283
C18	Amplifier board	30194
C22	HV amplifier board	30288
C27	3 kv transformer board	32176
F101 and F102	Fuse, 1.5 amp, SLO-BLO	08627
I1	1.5KV, indicator lamp	00922
I2	3KV, indicator lamp	00922
J1	PRINTER, 50-pin connector	21216

MODEL 530 SPECTROMETER PARTS LIST (Cont.)

REF. DESIG.	NAME OF COMPONENT AND DESCRIPTION	PART NUMBER
J2	1.5KV OUT, MHV connector	00698
J3	CURRENT INPUT, MHV connector	00698
J4	PRE-AMP, 7-pin connector	00742
J5	VOLTAGE INPUT, BNC connector	00756
J6	ANALYZER OUTPUT, BNC connector	00756
J7	3KV OUT, MHV connector (UG931/U)	00698
P1	FINE GAIN, potentiometer, 6 k, 2 watt, $\pm$ 5%	32213
P2	LOWER LEVEL, potentiometer, 1 k, 2 watt, 10-turn	30390
P3	WINDOW, potentiometer, 1 k, 2 watt, 10-turn	30390
PB1	START, pushbutton switch (black)	01255
PB2	STOP, pushbutton switch (red)	03124
PB3	CHANNEL RESET, pushbutton switch	02155
R1	Resistor, 4.02 k, 1/4 watt, $\pm$ 1%	32212
R2	Resistor, 36 k, 1/3 watt, $\pm$ 1%	32210
R3	Resistor, 500 k, 4 watts, $\pm$ 1%	32211
R4	Resistor, 5 ohms, 10 watts, $\pm$ 5%	04226
R5	Resistor, 220 k, 2 watts, $\pm$ 5%	01093

MODEL 530 SPECTROMETER PARTS LIST (Cont.)

REF. DESIG.	NAME OF COMPONENT AND DESCRIPTION	PART NUMBER
R6	Resistor, 100 k, 1/2 watt, ± 1%	01148
R7	Resistor, 20 m, 2 watt, ± 1%	08054
R101 and R105	Resistor, 90.9 ohms, 1/4 watt, ± 1%	30265
R102 and R106	Resistor, 191 ohms, 1/4 watt, ± 1%	30266
R103 and R107	Resistor, 412 ohms, 1/4 watt, ± 1%	30267
R104	Resistor, 953 ohms, 1/4 watt, ± 1%	30269
R108	Resistor, 43 k, 1/2 watt, ± 5%	30371
R109	Resistor, 36 k, 1/2 watt, ± 5%	00343
R110	Resistor, 24 k, 1/2 watt, ± 5%	00350
R111	Resistor, 13 k, 1/2 watt, ± 5%	00364
R201 and R202	Resistor, 500 k, 4 watts, ± 1%	32211
R203, R204) R205, R206)	Resistor, 100 k, 1/3 watt, ± 1%	30346
R207	Resistor, 50 k, 1/4 watt, ± 1%	30345
R208, R209) R210, R211)	Resistor, 10 k, 1/4 watt, ± 1%	30344
S1	PSC-BS, slide switch, SPDT	30367
S2	0.1 SEC-0.1 MIN, slide switch, SPDT	30367
S3	MAN-AUTO-TEST, slide switch, SPTT	30366

MODEL 530 SPECTROMETER PARTS LIST (Cont.)

REF. DESIG.	NAME OF COMPONENT AND DESCRIPTION	PART NUMBER
S4	ON-POWER-OFF, toggle switch, SPST	30341
S5	INT-DIFF, slide switch, SPDT	30367
S6	MAN-AUTO, slide switch, 4PDT	30368
S7	ON-STANDBY, slide switch, SPDT	30367
S8	COARSE GAIN, rotary switch, 4-pole, 2-6 position	30376
S9	COARSE ADJUST, rotary switch, 3 pole, 10 position	32216
S10	FINE ADJUST, rotary switch, 2-pole, 2-12 position	32217
S11	SAMPLE CHANGER IN-OUT, slide switch, DPDT	30472
S12	Interlock switch (behind front panel; turns HV on)	30320
S15	HV RANGE, rotary switch, 5-pole, 2-position	32215
	Cabinet (including stand)	31471
	Connector, 23-pin	30289
	Dial, 10-turn	31073
	Display window	30228
	Instruction manual	31426
	Knob, finger grip lock	31112
	Knob, pointer lock	31113

MODEL 530 SPECTROMETER PARTS LIST (Cont.)

REF. DESIG.	NAME OF COMPONENT AND DESCRIPTION	PART NUMBER
	Knob, round skirted	30393
	System supply, LV	30571

DIGITAL-TO-ANALOG CONVERTER PARTS LIST

REF. DESIG.	NAME OF COMPONENT AND DESCRIPTION	PART NUMBER
*C1	DAC scaler control board	32028
*C14	Triple decade buffer and DAC board	32399
R2	SPAN ADJ, potentiometer, 2 k, 2 watts, 10%	01087
S13	DAC RANGE, rotary switch, 12-pole, 4-position	32400
S14	100MV-1MA, recorder slide switch, DPDT	30472
	RECORDER, terminal strip, 6-terminal	01359

*Model 530 printed circuit board location

APPENDIX

MODEL 530 SPECTROMETER SCHEMATIC DRAWINGS

DWG. NO.	NAME
C-30086	System Supply
D-30179	1 mc Decade Counter
D-30180	100 kc Decade Counter
D-30181	Timer Count Down
D-30184	Amplifier
D-30203	Scaler Control
D-30204	Analyzer
B-30238	HV Supply Coarse & Fine Adjust
B-30240	Amplifier Coarse Gain Switch
D-30241	HV Amplifier
E-30326	Model 530 Spectrometer Logic Diagram
D-32173	3KV Transformer

DIGITAL-TO-ANALOG CONVERTER SCHEMATIC DRAWINGS

DWG. NO.	NAME
D-30961	DAC Scaler Control
D-31620	Model 530 Switching for Triple Decade Buffer and DAC Logic Diagram
D-32380	Triple Decade Buffer and DAC

BAIRD ATOMIC

33 UNIVERSITY ROAD CAMBRIDGE 38, MASS.

TELEPHONE UNIVERSITY 4-7420